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April 1981
Final Report

DOT HS-805-960

U.S. Department of Transportation
National Highway Traffic Safety Administration

Upgrade Volvo Production Restraint Systems

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Minicars, Inc.
55 Depot Road
Goleta, CA 93117

Contract No. DOT HS-9-02178
Contract Amount $336,744

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Technical Report Documentation Page

1. Report No. DOT-HS-805-960	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle UPGRADE VOLVO PRODUCTION RESTRAINT SYSTEMS		5. Report Date APRIL 1981
		6. Performing Organization Code
7. Author(s) M. Foster, W.G. Broadhead and D.T. Zinke		8. Performing Organization Report No. FR-1094-04-81
9. Performing Organization Name and Address Minicars, Inc. 55 Depot Road Goleta, California 93117		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT-HS-9-02178
12. Sponsoring Agency Name and Address Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, S.W., Washington, DC 20590		13. Type of Report and Period Covered FINAL REPORT June 1979 to March 1981
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

A production air cushion restraint system, developed by Volvo for their 1975 Model 244, was upgraded to provide 40 mph barrier equivalent velocity (BEV) frontal impact protection for the driver and front seat passenger. The effort included a series of vehicle barrier crashes and a large amount of developmental sled testing. The 1979 Volvo 242 and 244 production seat belt restraints were also upgraded; a simple modification allowed the protection of front seat occupants at 35 mph BEV. This was again accomplished through developmental sled testing and an evaluative barrier impact.

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17. Key Words Volvo, Airbag, Air Cushion Restraint, Automobile Occupant Restraints, Seat Belts	18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	412	

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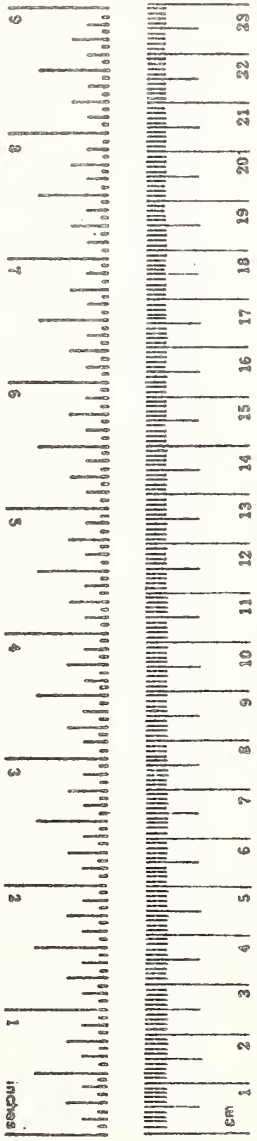
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

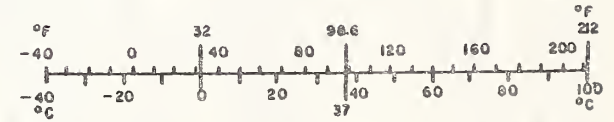
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECTION 1
INTRODUCTION

In 1975 Volvo manufactured 75 model 244's with fully production engineered front seat air cushion restraint systems. Most of these vehicles were leased to the insurance industry (and the remainder retained by Volvo) for on-the-road evaluative testing. The vehicles, which currently are coming out of service, were the basis for the research and development work of this contract.

In previous testing conducted by the National Highway Traffic Safety Administration (NHTSA) and by the Volvo Corporation, these production airbag systems passed, with ample margin, the FMVSS 208 requirements for the 30 mph frontal impact protection of 50th percentile male occupants. In further NHTSA and Volvo testing with 50th percentile male dummies the passenger system passed the FMVSS 208 requirement at 40 mph barrier equivalent velocity (BEV), while the driver system produced HIC measurements in the 1200 to 1300 range and chest accelerations around 65 Gs. The frontal head-on performance limits of the Volvo production driver system therefore appeared to be about 35 to 37 mph BEV.

Two other NHTSA contracts, however, indicated that this production driver system could be upgraded (with minor modifications) to full 40 mph BEV frontal protection capability. Thus, the overall objective of this program was to demonstrate 40 mph BEV frontal protection with modified Volvo driver and passenger air cushion restraint systems. This was accomplished via production oriented modification of the stock Volvo driver system and an updating of both systems to the latest technology in pure pyrotechnic inflators.

This contract also emphasized the improvement of the passenger system to mitigate the injuries of forward positioned children. High performance bags, which are tailored primarily to the protection requirements of a normally seated adult (at the expense of out-of-position children), were not acceptable. At the same time, however, restraint performance for adults was not to be unduly sacrificed, since the injuries of adults bring about the highest societal costs of accidents. These two seemingly contradictory objectives were, nevertheless, met in the design of the Volvo passenger system.

The approach taken in this program involved a series of exploratory vehicle barrier crashes, a series of developmental sled tests, and by two integration/evaluation barrier impacts. In addition, a second sled test series further developed the passenger system to provide protection to a forward positioned child occupant. A final barrier impact then evaluated this system.

The initial vehicle barrier impacts were conducted in order to define the problems with the driver restraint system at the 40 mph impact velocity, and to determine which design options might be solutions to those problems. The focus of these tests was on the problems of compartmental intrusion and column instability – and on the isolation of the restraint systems from such problems. Sierra Part 572 50th percentile male surrogates, instrumented with head and chest triaxial accelerometers and femur load cells, were used to evaluate the restraint systems. The head injury criterion (HIC) measurement was calculated from the resultant head acceleration sustained in each crash.

Once the specific problem areas were identified, the developmental sled testing began. The design solutions were refined and optimized (again with 50th percentile male dummies) and were later evaluated with 5th percentile female and 95th percentile male dummies. When the performance was consistently satisfactory, two more barrier impacts were conducted to finalize and evaluate the systems.

The second sled test series was then conducted on the passenger system. The primary goal with this series was to redesign the system to accommodate a full range of occupant sizes and positions. The specific focus was injury mitigation for forward positioned children (yet retention of the 40 mph BEV protection for adults). Both an Alderson 3-year-old child surrogate (instrumented with head and chest triaxial) accelerometers) and a 50th percentile male dummy were used in this phase of the testing. A dual level system, using two pyrotechnic inflators, was developed during the sled test series and later evaluated in a final barrier impact.

This report describes the development of the modified Volvo driver and passenger air cushion restraint systems – from the exploratory crash tests, through the developmental sled tests and on to the evaluative barrier impacts. It also

describes a major contract modification in which the Volvo production seat belt systems were upgraded to provide 35 mph BEV protection. This modification came about in response to a test conducted under the NHTSA's New Car Assessment Program (NCAP). The results of that test indicated that a significant improvement in the Volvo's seat belt protection capabilities could be obtained through minor modifications to the system. Under this contract modification Minicars conducted a developmental sled test series and two evaluative barrier tests (in which these goals were met).

SECTION 2
VOLVO DRIVER AIRBAG RESTRAINT SYSTEM

2.1 INTRODUCTION

The Volvo production driver airbag system has three major energy absorbing components: a steering wheel mounted airbag, a collapsing steering column and a knee restraint (pad). The geometrical layout of these components is illustrated in Figure 2-1; their placement in the driver's station is shown in Figure 2-2.

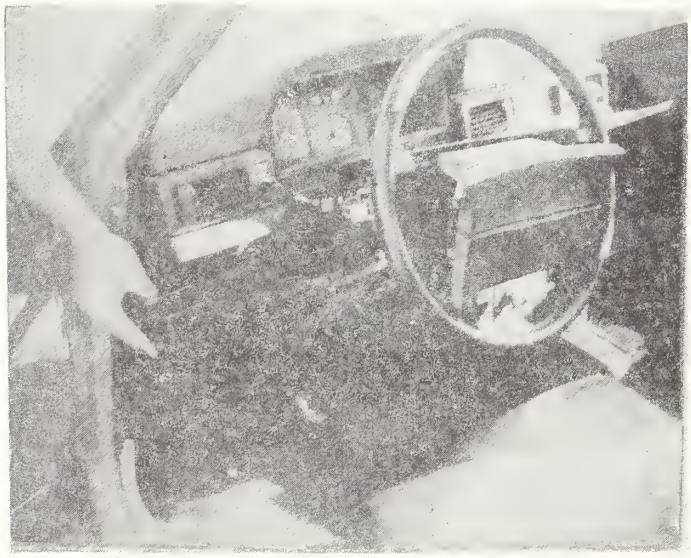
The inflator/airbag module is mounted in the center of a specially designed Volvo steering wheel, which also absorbs energy through controlled spoke deformation (Figure 2-3). The pressed steel module box contains a stored gas inflator and a vented neoprene coated nylon airbag. This inflator/airbag module (shown in Figure 2-4) is produced by Eaton Safety Systems.

A knee restraint controls the driver's lower body kinetic energy. This restraint, which is bolted to the bottom of the column mounting crossmember, is a 2 inch thick section of rigid foam backed by a deforming sheetmetal reaction surface and covered with a thick black plastic fascia (Figure 2-5).

The steering column is a stock Volvo energy absorbing unit (Figure 2-6) with a maximum stroke of 4 inches and a collapse force averaging about 800 pounds. The forward end of the steering column mounts on a bracket secured to the firewall. The aft end attaches through two plastic shear capsules to a crossmember located just underneath the column (Figure 2-7). When the driver impacts the wheel during a crash, the plastic capsules slide free, allowing the column to stroke axially. A section of the outer tube of the column is corrugated; the column strokes when this section compresses.

FIGURE 2-1. VOLVO DRIVER RESTRAINT GEOMETRY

(a) Installed Restraint System



(b) Partially Removed Restraint System

FIGURE 2-2. DRIVER STATION INTERIOR

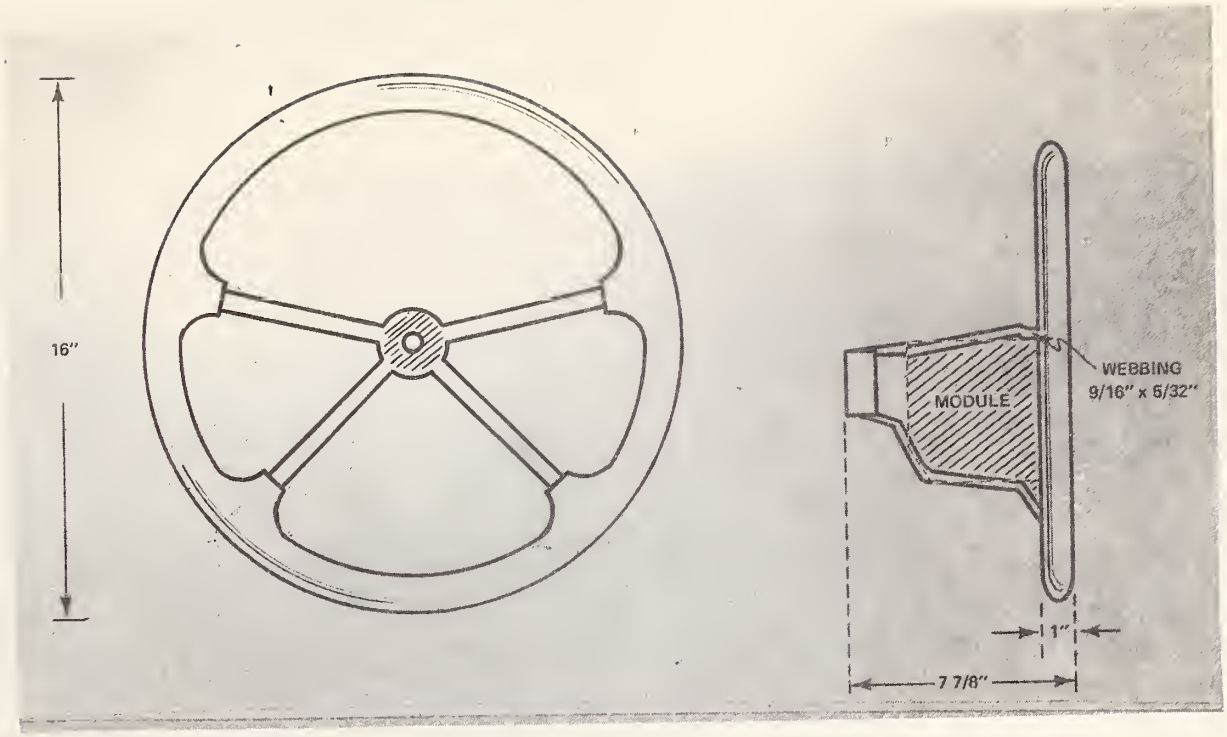


FIGURE 2-3. VOLVO AIRBAG STEERING WHEEL

FIGURE 2-4. STEERING WHEEL INTEGRATED AIRBAG SYSTEM

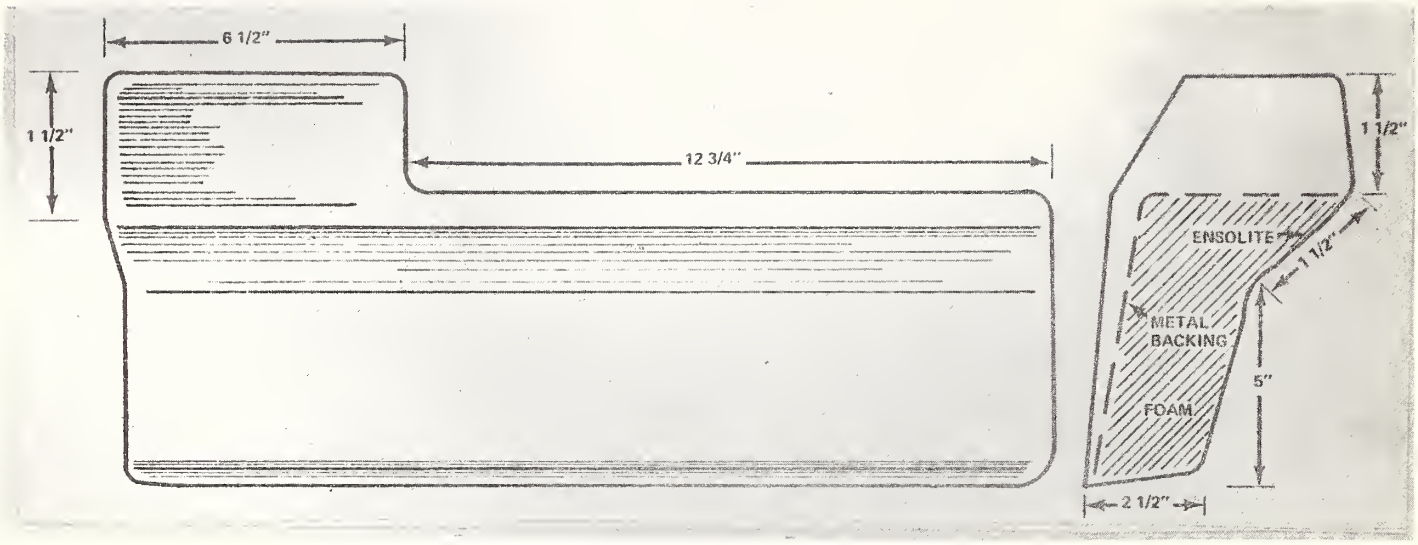


FIGURE 2-5. DRIVER KNEE RESTRAINT

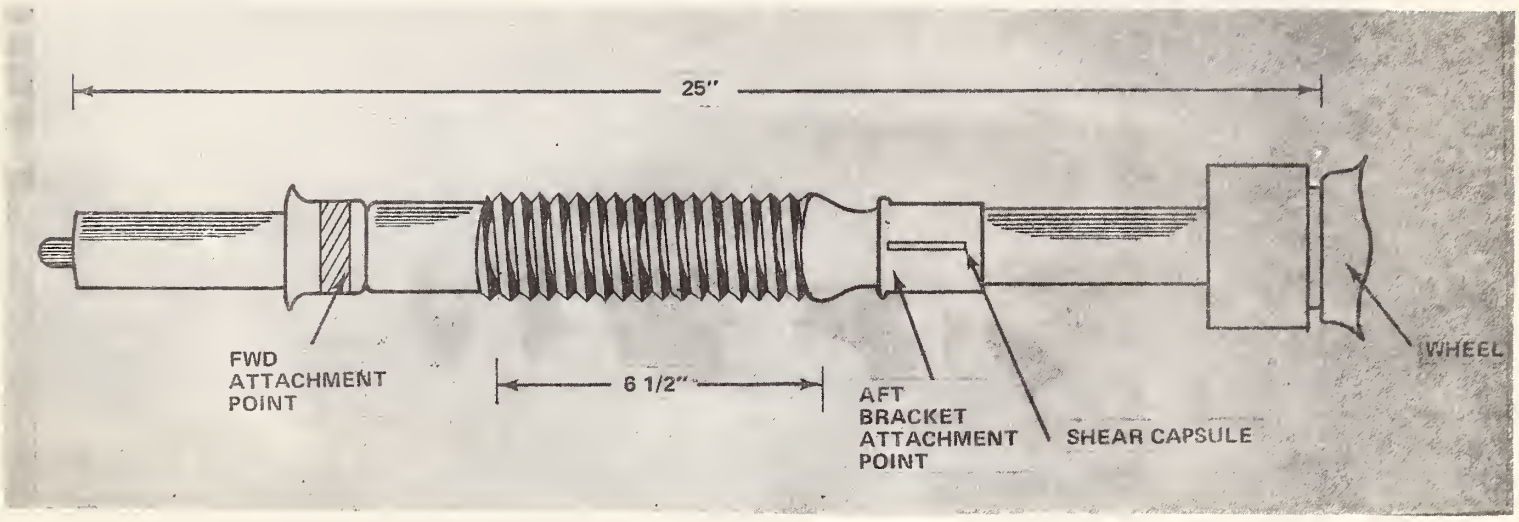


FIGURE 2-6. STOCK VOLVO EA STEERING COLUMN

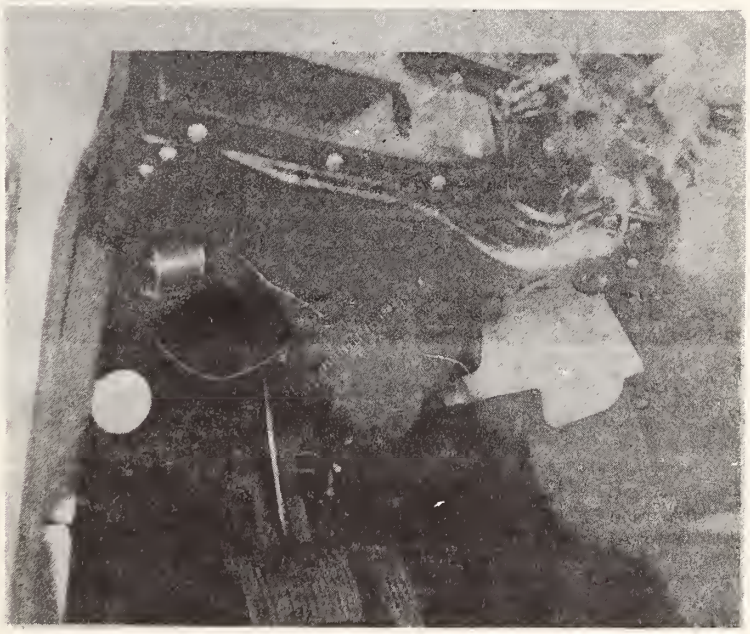


FIGURE 2-7. CROSSMEMBER BENEATH THE COLLAPSING STEERING COLUMN

2.2 INITIAL VOLVO BARRIER TEST (TEST 1519)

Preparation

This contract's first driver airbag test was an exploratory vehicle barrier crash conducted to provide baseline information on the restraint system. One of the objectives of this contract was to tune the Volvo restraint system using solid pyrotechnic inflators. For this reason, the production Eaton stored gas inflator module was replaced by a system designed by Fitzpatrick Engineering for the Calspan RSV. The Fitzpatrick system consists of an untethered airbag, a reinforced Volvo airbag steering wheel, a sheetmetal module box and a 110 gram Thiokol driver inflator (Figure 2-8).

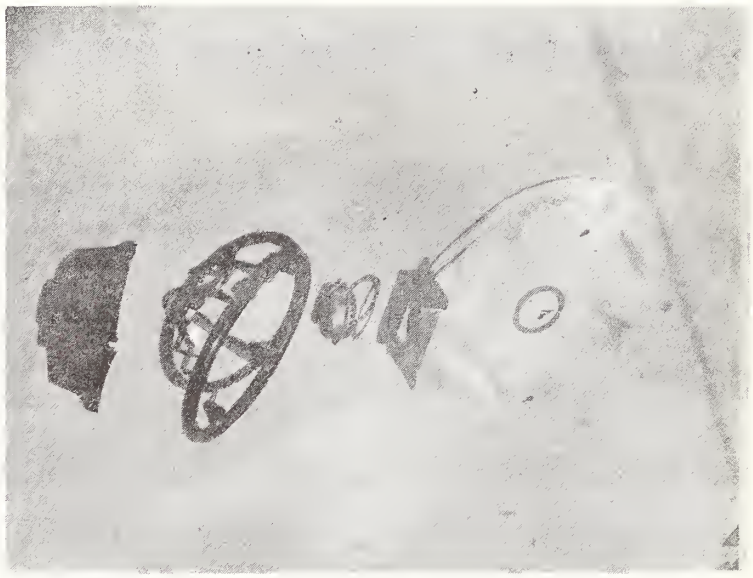


FIGURE 2-8. AIRBAG SYSTEM

The coated nylon airbag is 28-1/2 inches in diameter (flat pattern) and has a 2 inch diameter vent. The production Volvo airbag steering wheel was reinforced (to increase its collapse force) by 0.090 inch thick steel strips welded along the length of each spoke. The module box was fabricated of 20 gauge steel. The

knee restraint and the steering column were unchanged, but the link connecting the steering shaft to the steering gearbox was removed to eliminate the possibility of column intrusion caused by rearward axial loads transmitted through this link. (In later testing this link was replaced by one that did not transmit compression or bending.) The seat was placed 1-1/2 inches behind the middle position (which is comfortable for the 50th percentile male). Only the driver system was evaluated in this test. The passenger system was omitted so that there could be unrestricted camera coverage of the driver system.

Results

The data traces for all of the tests conducted under this contract are contained in the appendix. Table 2-1 summarizes the results of all driver barrier and sled tests.

The first barrier crash went remarkably well. All of the driver's injury measurements were below the FMVSS 208 criteria – although the chest acceleration (56 Gs) should be lower. Unfortunately, the way in which the column translated was not repeatable on the sled, and it was questionable whether this system would adequately protect different size occupants. When the driver contacted the airbag, the aft end of the column separated from the crossmember on which it was mounted and rotated upward (rather than stroking axially). Firewall intrusion moved the lower (forward) column mount rearward, compressing the energy absorbing unit and reorienting the column into a much more vertical position (Figures 2-9 and 2-10). Obviously, this reorientation would not be beneficial to all occupant sizes.

2.3 SECOND VOLVO BARRIER TEST (TEST 1555)

Preparation

Because of the column behavior, we decided to conduct a second vehicle barrier test with a different column support. The new support, which was designed to hold both the upper and lower attachment points of the column, was welded to the

TABLE 2-1. DRIVER SYSTEM TESTS

Test	Changes Since Last Test	Speed (mph)	Column Stroke (inches)	Knee Restraint	Knee Stroke (inches)		HIC	Chest Acceleration (Gs 3 msec)	Femur Loads (pounds)		See Note
					Left	Right			Left	Right	
1519 (Barrier)	Initial vehicle barrier test.	40.5	3-1/2	Stock	Bottom	Bottom	456	56	1500	1900	
1555 (Barrier)	Column hold down bracket. Moving knee restraint with strap & roller EA units.	40.5	0	Moving knee restraint 1500 pound EAs.	Foam bottom EA 0	Foam bottom EA 2-1/2	435	62	2600	2600	
1568 (Barrier)	Pivoting knee restraint to control translation with plastic hinge EAs.	40.5	5/8	Pivoting knee restraint 1100 pound EAs.	Foam bottom EA 3.5	Foam bottom EA 3.5	552	60	2500	2400	
1585 (Sled)	Initial sled test with rigid knee restraint.	40.5	2-1/2	Pivoting knee restraint rigid with no EAs.	Bottom	Bottom	595	66	3150	3000	
1591 Sled)	GT wheel with 0.180 inch spoke reinforcement. Plastic hinge EA knee restraint.	39.4	1-11/16	Pivot knee restraint with 1700 pound EAs.	Foam bottom EA 1.25	Foam bottom EA 1.25	381	73	1600	1600	

TABLE 2-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Column Stroke (inches)	Knee Restraint	Knee Stroke (inches)		HIC	Chest Acceleration (Gs 3 msec)	Femur Loads (pounds)		See Note
					Left	Right			Left	Right	
1619 (Sled)	- Squib delay from 10 to 8.6 msec. - Knee restraints of plastic covered foam. (Abandoned the plastic hinge.) - Plastic housing placed between wheel and dash. - Partial dash installed to provide a reaction surface for plastic housing. - Unaltered Volvo GT wheel. - Added column force & displacement instrumentation.	40.2	1.5	Foam	Full	Full	789	65	1200	2400	a
1626 (Sled)	LRSV type bag & inflator. Smaller bag & Talley 145 gram inflator.	39	1-3/16	Foam	Full	Full	286	47	2000	2700	b
1639 (Sled)	Volvo #3 bag – 28 inch diameter, 1-5/8 inch vent. Styrofoam replaced plastic housing. 50 percent thicker spokes.	39.7	1.5	Foam	Full	Full	556	55	2050	2200	

NOTES:

a. Knee restraints worked well. Some yielding of the knee restraint reaction pan.
b. Knee bar interfered with column stroke.

TABLE 2-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Column Stroke (inches)	Knee Restraint	Knee Stroke (inches)		HIC	Chest Acceleration (Gs 3 msec)	Femur Loads (pounds)		See Note
					Left	Right			Left	Right	
1655 (Sled)	Intrusion independent restraints mounting cross-member installed. Deeper knee restraint.	40.4	2	Foam	Full	Full	497	55	1600	1200	c
1663 (Sled)	Shallower knee restraint to reduce submarining. Changed from Talley 145g inflator to Thiokol 120g inflator (due to lead time and hardware availability).	40.4	1.88	Foam	Full	Full	299	50	1500	1100	d
1697 (Barrier)	System identical to sled Test 1663.	40.2	2	Foam	Full	Full	419	72	1700	3400	e
1713 (Barrier)	Heater removed to allow cross-member to yield.	40.2	2-3/4	Foam	Full	Full	404	57	1350	2800	f
1718 (Barrier)	Heater installed. Crossmember modified to clear heater. Otherwise identical to Test 1663.	40.0	1-3/4	Foam	Full	Full	440	58	2100	1800	g
1969 (Barrier)	Repeat of Test 1718.	40.25	1/4	Foam	Full	Full	610	69.2	1380	2380	h

NOTES:

c. Slight submarining near end of event.
d. Good test results.
e. Heater system did not allow restraints crossmember to yield (resulting in high chest Gs). Right femur deprived of stroking by crossmember.
f. Right knee deprived of stroking by crossmember.
g. All injury measurements below the FMVSS 208 criteria.
h. Column failed to stroke, causing injury measurements in excess of FMVSS 208 criteria.

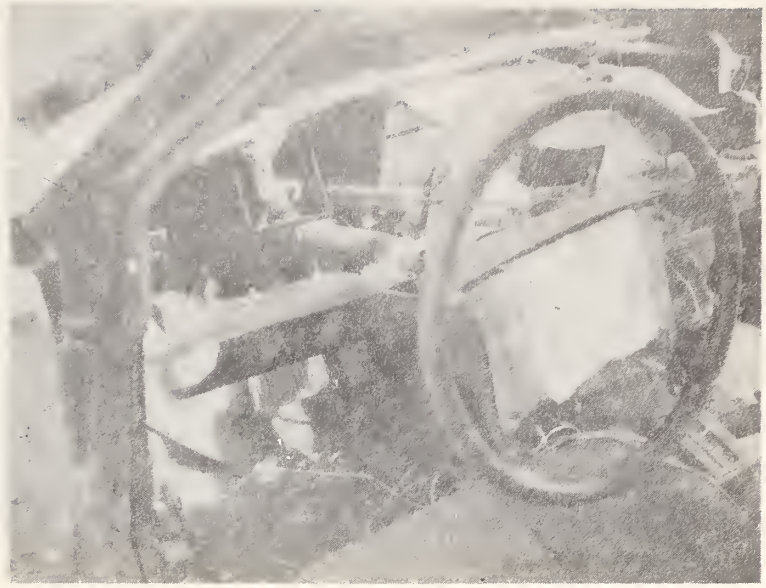


FIGURE 2-9. PRE-CRASH STEERING COLUMN AND WHEEL

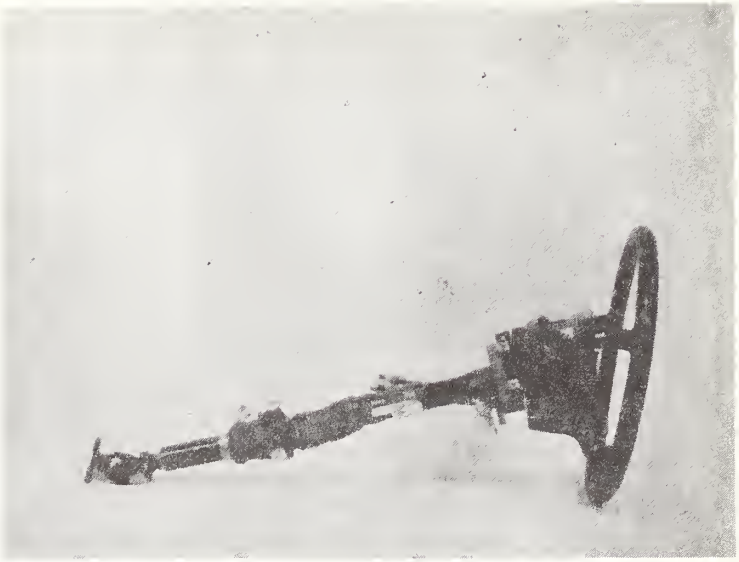


FIGURE 2-10. POST-CRASH STEERING COLUMN AND WHEEL

cowl (instead of the firewall), so that the effects of firewall intrusion would be minimized (Figure 2-11). The upper (aft) column mount was removed from the knee restraint crossmember, turned over, and reattached to the new support (this change allows the upper end of the column to be guided axially when it separates from the shear capsules). The knee restraint was then redesigned to break away from its mounts and to translate under the control of energy absorbing steel tape and roller units (Figure 2-12).

The reinforced steering wheel, module pan and inflator were left unchanged for this test. The airbag vent diameter was reduced from 2 to 1-1/2 inches in an attempt to prevent the dummy from penetrating through the bag. (Penetration became more of a problem because the axially compressing column supported higher loads than did the rotating column.)

Results

The injury measurements on the driver were slightly higher than the FMVSS 208 criteria allow. The chest acceleration was 62 Gs and the femur loads were both 2600 pounds. The knee restraint pivoted upward because the energy absorbing mounts were not strong enough to keep it oriented with the knees. This allowed the knees to pass underneath the restraint and to strike the intruding firewall (thereby producing the high femur loads). The excessive knee translation also caused the driver's lower torso to contact the lower wheel rim, resulting in the 62 G chest acceleration.

2.4 THIRD VOLVO BARRIER TEST (TEST 1568)

Preparation

The knee restraint mounting and energy absorption system was redesigned for the third vehicle crash test. To properly control the articulation of the knee restraint we attached a pair of pivot arms to the restraint; the arms extended vertically to pivot points near the floor. This design ensures that the knee restraint translates along a predetermined arc (Figure 2-13). Plastically

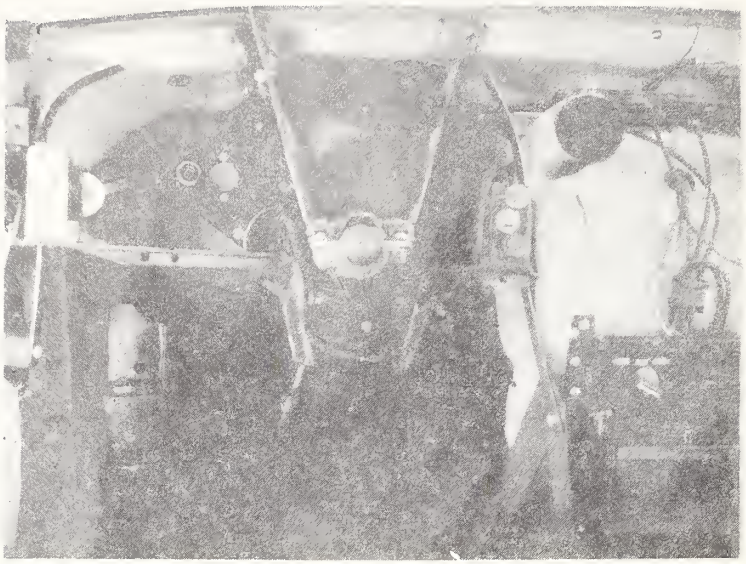


FIGURE 2-11. COLUMN MOUNTED IN CAR

FIGURE 2-12. EA UNITS MOUNTED ON THE MODIFIED CROSSMEMBER

FIGURE 2-13. INSTALLED KNEE RESTRAINT SYSTEM

deforming sheetmetal hinges between the knee restraint and the cowl abs lower body energy. The steering column, column mounting, steering wh inflation system were unchanged from the previous test.

Results

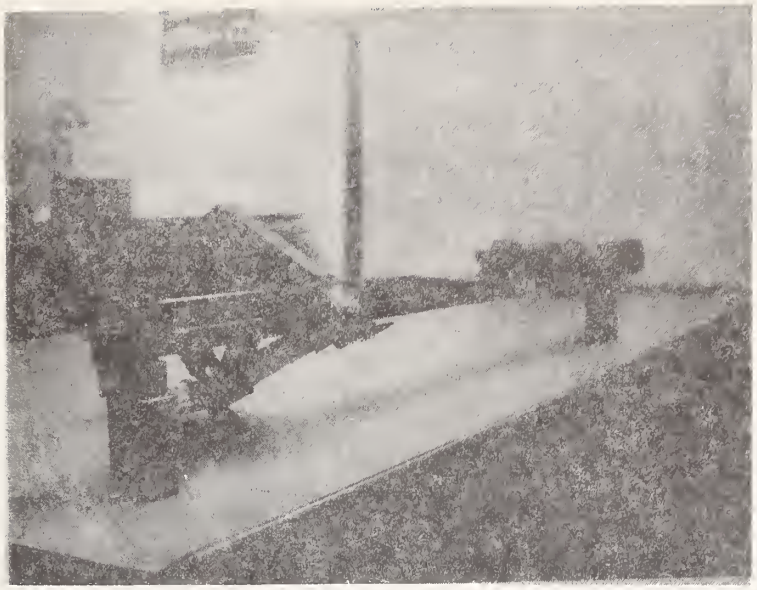
The driver barely failed the FMVSS 208 injury criteria (chest acceleration 60 Gs and femur loads 2400 and 2500 pounds). The knee restraint stroked at too low a force and allowed a submarine trajectory (instead of the desired slight pitching trajectory). This caused the driver's lower torso to strike the lower wheel rim, producing heavy uploads which bent the column slightly and limited its axial collapse to only 5/8 inch.

2.5 DRIVER RESTRAINT SYSTEM SLED TESTS

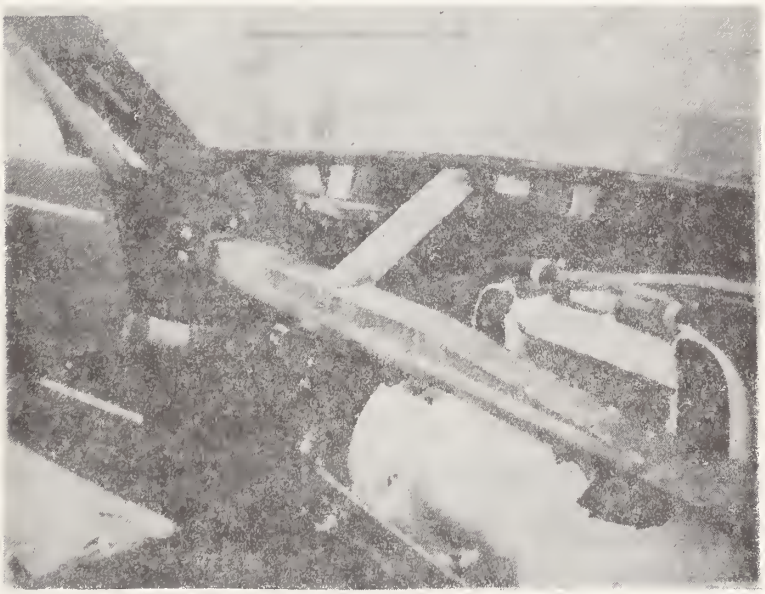
This sled test series began with the same system as in the third barrier test. During Sled Tests 1585, 1591, 1619, 1626 and 1639 a number of changes were made to tune the system at 40 mph with the 50th percentile male. First, the pivoting knee restraint was replaced with a more conventional fixed knee restraint; the fixed restraint was composed of 6 inches of energy absorbing foam backed by a deforming sheetmetal reaction plate. Then the steering wheel, inflator and airbag vent were all changed (though the steering column mount remained the same). A Volvo "GT" steering wheel (smaller than the stock airbag wheel) was adapted to the system and reinforced by 0.075 inch thick steel strips welded along the full length of each spoke. The inflator was changed from a 110 gram Thiokol to a larger 145 gram Talley driver inflator. The airbag vent size was increased from 1-1/2 to 1-5/8 inches in diameter. With these changes all of the injury measurements (Test 1639) were reduced below the FMVSS 208 criteria; however, the chest acceleration (55 Gs) and femur loads (2050 and 2200 pounds) were still slightly high.

At this point in the sled test series we designed a more production oriented mounting system for the column and knee restraints. The new mount was a box section sheetmetal crossmember attached directly to the two A-pillars and connected to the cowl by box section struts (see Figure 2-14). The column mounted on the lower side of this crossmember; the forward column mount also attached to the cowl (away from the firewall). The sheetmetal bracket for the foam knee restraint was attached on its top edge to the crossmember and on its lower edge (via steel straps) to the A-pillar on one side and to an upright bracket from the tunnel on the other. This restraints mounting crossmember was expected to isolate the column and knee restraints from the effects of firewall intrusion.

Two sled tests (Tests 1655 and 1663) were conducted with this crossmember. The depth of the knee restraint was increased to 8-1/2 inches in Test 1655. However, because of reduced knee translation it was decreased to 6-1/2 inches in Test 1663. The wheel, column, and airbag remained the same, but limited availability of the Talley inflator required us to change, in Test 1663, from the 145 gram Talley unit to a 120 gram Thiokol lightweight driver inflator.



(a) Complete Bracket



(b) Installed in Volvo 244

FIGURE 2-14. INTRUSION INDEPENDENT COUPLER AND KNEE RESTRAINT SUPPORT BRACKET

Test 1663 was the last sled test of the driver restraint system. The injury measurements on the 50th percentile male dummy were all below the FMVSS 208 criteria – with the chest acceleration down to 50 Gs and the femur loads to 1500 and 1100 pounds.

2.6 FOURTH VOLVO BARRIER TEST (TEST 1697)

Preparation

The driver restraint system used in Test 1663 was then mounted in the fourth Volvo barrier test vehicle. The only difference was the presence of the stock Volvo heater (none had accompanied any of the sled tests). As it turned out, the heater played an important role in the function of the restraint system by adding structural support to the intrusion independent restraints mounting crossmember. The remainder of the system was unchanged from sled Test 1663; this system had a stock column, a reinforced (0.075 inch thicker spokes) Volvo "GT" wheel, a 120 gram Thiokol inflator, a 28-1/2 inch diameter airbag with a 1-5/8 inch vent, and a 6-1/2 inch deep knee restraint.

Results

Some of the driver's injury measurements exceeded the FMVSS 208 criteria. The chest acceleration was much too high (72 Gs), and the right femur, which was deprived by the heater of several inches of energy absorbing displacement, peaked at 3400 pounds.

In this restraint system the occupant's energy is absorbed through the combined deformations of the components. During this test the stock Volvo heater provided enough structural support to the restraints mounting crossmember that the crossmember moved slightly rearward (instead of yielding forward as it did in the sled tests). But it was not clear how much the heater contributed, since the steering column was also deprived of several inches of displacement, and the torso received an extra deceleration because the legs had excessive femur loads.

2.7 FIFTH VOLVO BARRIER TEST (TEST 1713)

Preparation

Test 1713 was conducted to investigate the extent to which the restraint mounting crossmember is inhibited by the heater unit. The driver restraint system in this test was unchanged except for the omission of the heater unit.

Results

All of the driver's injury measurements, except the right femur (2800 pounds), were below the FMVSS 208 criteria. The right femur load was excessive because firewall intrusion wedged the lower leg between the toeboard and the crossmember. This prevented the knee from stroking further, thereby increasing the femur load. Surprisingly, the crossmember did not yield forward – but, still, the chest acceleration was improved (55 Gs). This may have been because the heater in Test 1697 actually pushed the crossmember until it moved slightly rearward. The high speed film also showed that the column stroked too early (and thereby reduced the ridedown).

2.8 SIXTH VOLVO BARRIER TEST (TEST 1718)

Preparation

The results of the fifth barrier test (Test 1713) indicated several areas of potential improvement in the driver restraint system. We modified the restraints mounting crossmember to accommodate an unaltered heater unit and to allow more vertical clearance for the driver's right knee. Figure 2-15 shows the modified crossmember. We also increased the height of the knee restraint's foam block and reaction plate and modified the Volvo steering column to improve its force deflection characteristics. The collapse force was increased from 800 to 1600 pounds by welding 1/8 by 3/8 inch steel strips to the side of the column (Figure 2-16). This change was designed to prevent the column from stroking too soon.

FIGURE 2-15. MODIFIED CROSSMEMBER

FIGURE 2-16. COLUMN WITH STEEL STRAPS ADDED

The rest of the system remained the same. The steering wheel, module pan and airbag are shown in Figure 2-17, the collapsible link (connecting the steering shaft to the steering gearbox) in Figure 2-18, and the knee restraint in Figure 2-19. The installed knee restraint and steering column are shown in Figure 2-20.

Results

The driver restraint system performed quite well in this test, maintaining all driver injury measurements below FMVSS 208 criteria. There was a substantial reduction in the right femur load (1800 pounds, as opposed to the 2800 pounds in Test 1713. The increased vertical clearance provided to the right knee by the altered crossmember was responsible for this improvement.

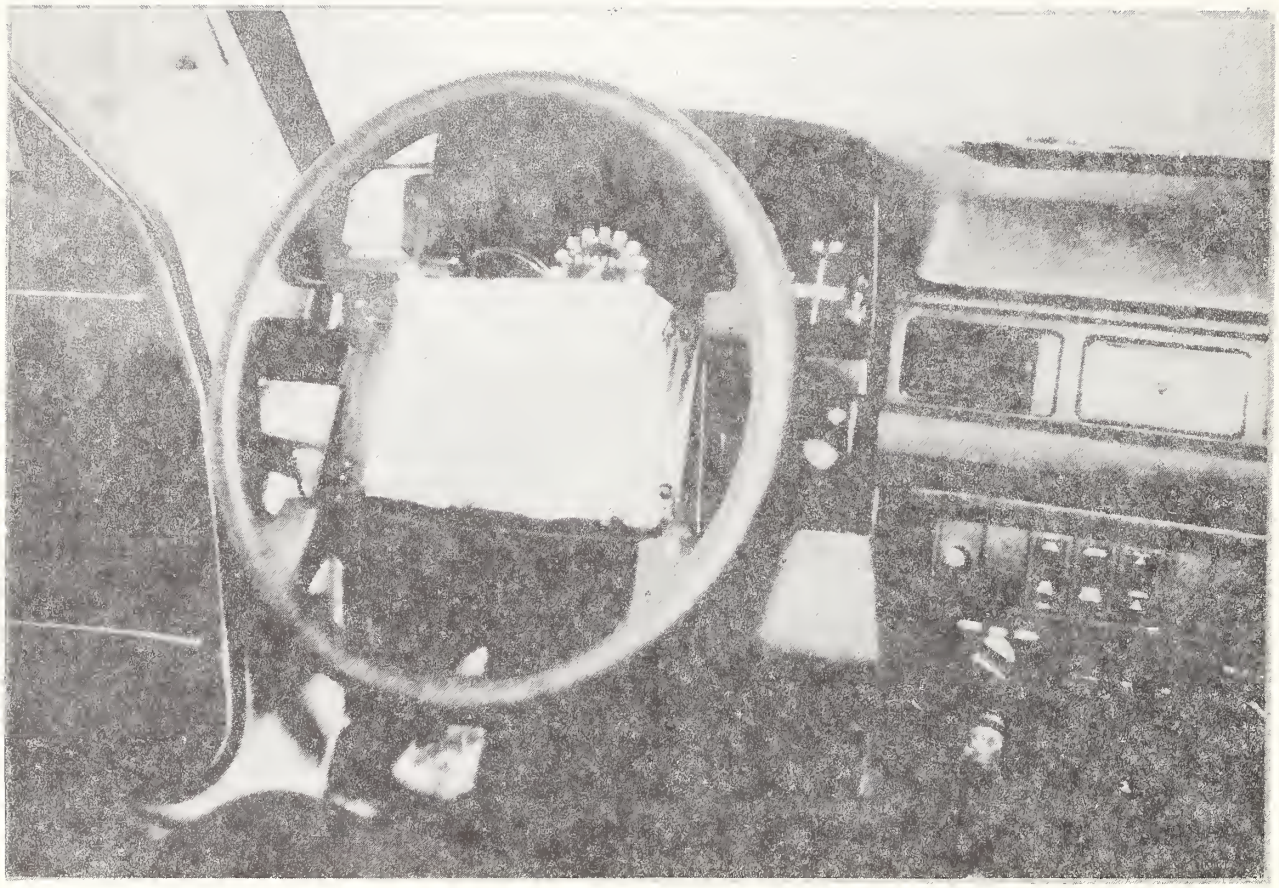


FIGURE 2-17. STEERING WHEEL WITH AIRBAG MOUNT

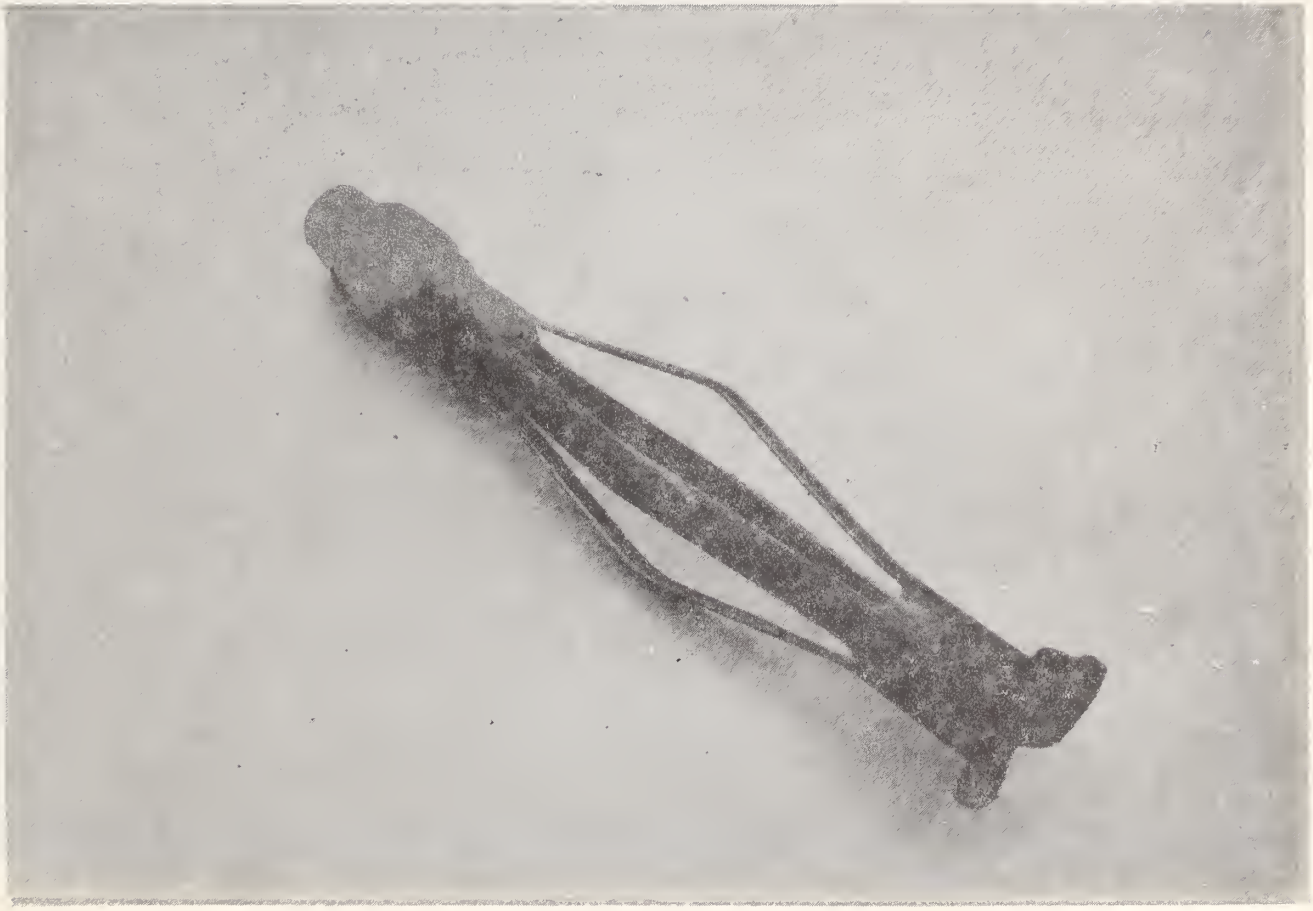


FIGURE 2-18. COLLAPSIBLE STEERING LINK

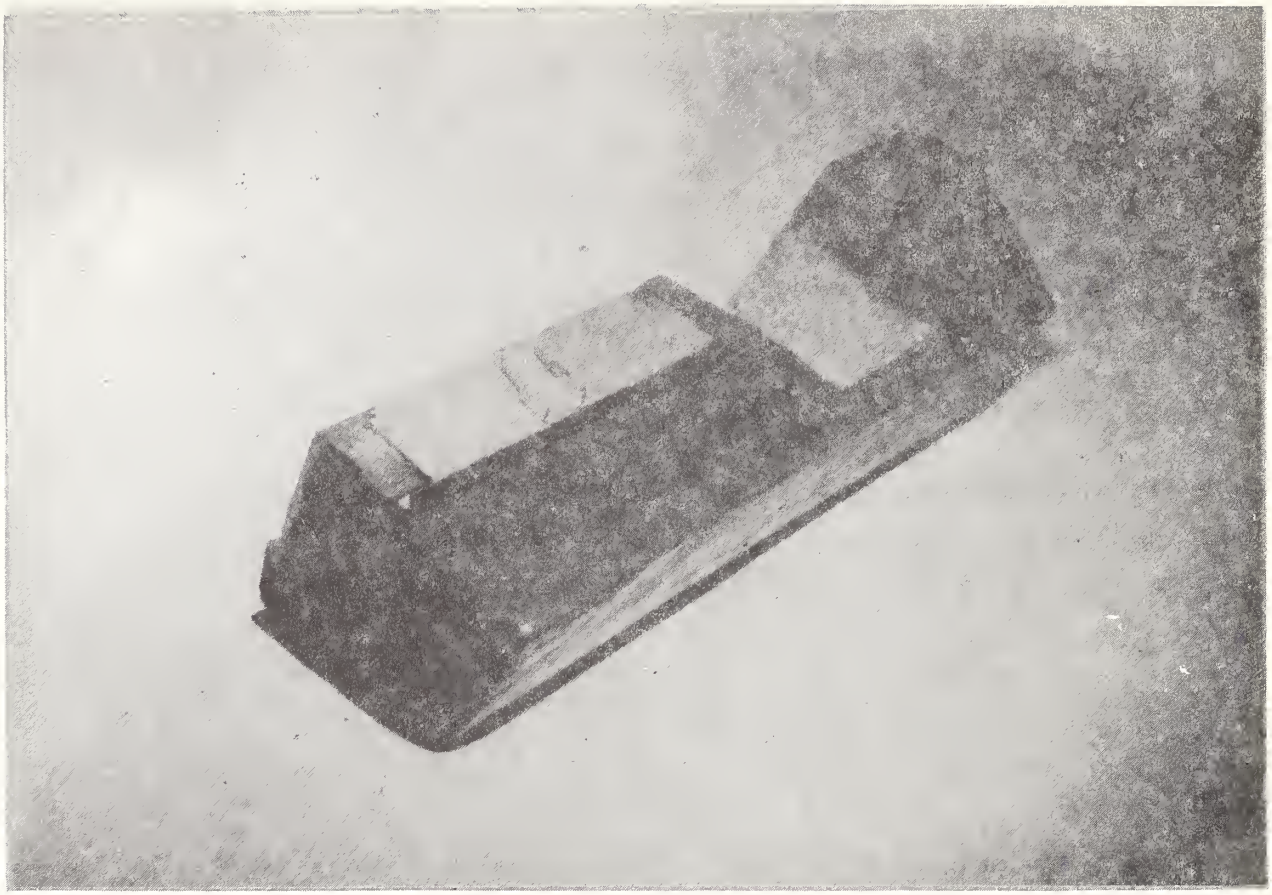


FIGURE 2-19. DRIVER KNEE RESTRAINT

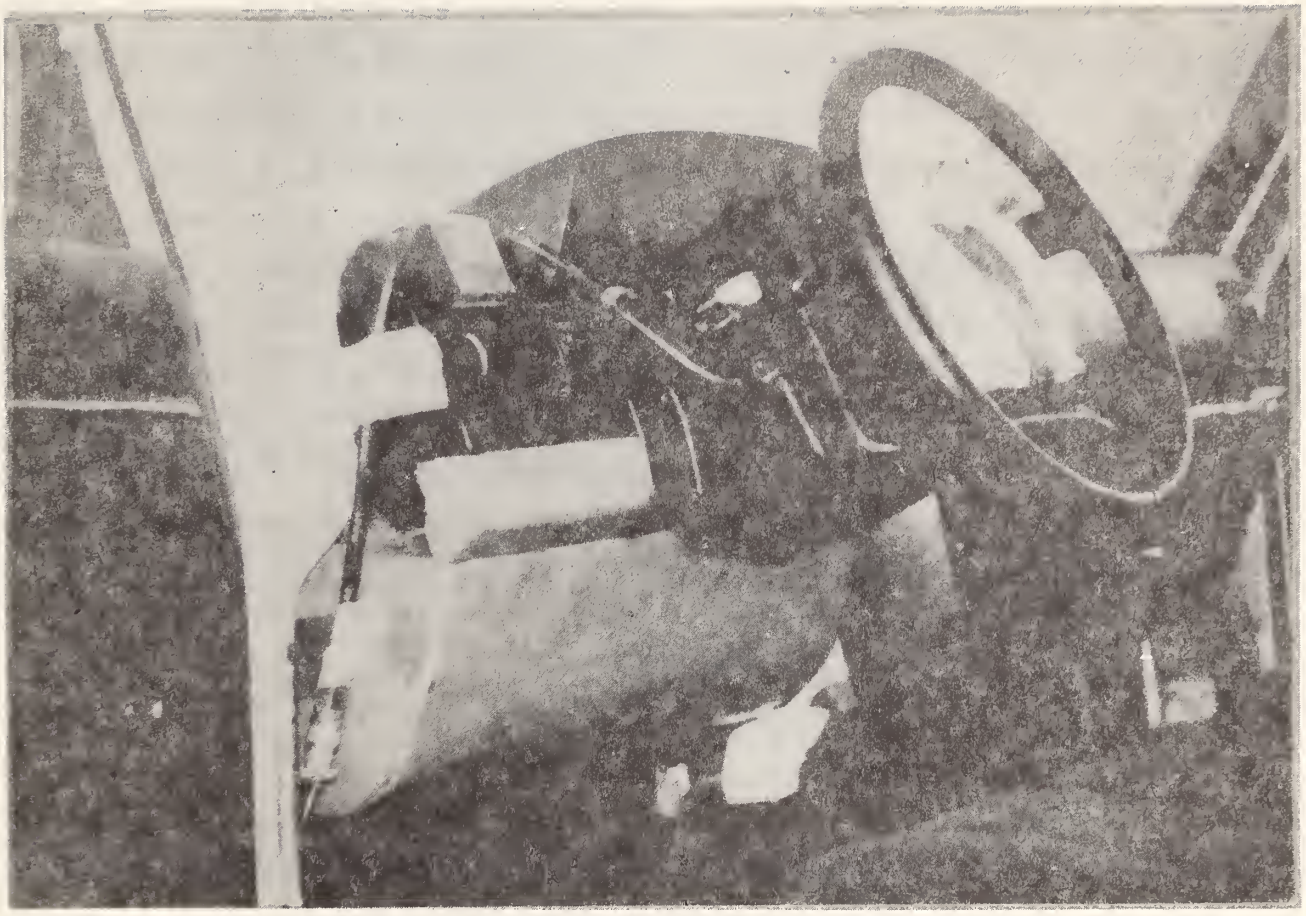


FIGURE 2-20. DRIVER RESTRAINT SYSTEM

2.9 SEVENTH VOLVO BARRIER TEST (TEST 1969)

Preparation

Test 1969 was the final 40 mph Volvo barrier test. On the driver side the airbag restraint system was set up identically to that installed in the previous barrier test (Test 1718). This test was conducted in order to determine the system's repeatability.

Results

The driver's chest acceleration exceeded the FMVSS 208 injury criteria because the modified Volvo steering column failed to stroke. The failure was a result of friction caused by heavy uploads. During the sled development of the system the column had exhibited unreliable and inconsistent stroking characteristics, with the stroke varying from 1/2 to 3-1/2 inches. (A more stable steering column, such as the Minicars RSV tube and mandrel column, would produce more repeatable results.) The steering wheel spokes deformed extensively and there was little evidence of lower wheel rim bending (which can indicate excessive local loading on the dummy's lower torso).

SECTION 3
VOLVO PASSENGER AIRBAG RESTRAINT SYSTEM

3.1 INTRODUCTION

The 1975 Volvo production passenger airbag system has two major energy absorbing components: an inflator/airbag combination to control the occupant's upper body energy, and a knee restraint to control the occupant's lower body energy. Figure 3-1 depicts the restraint geometry of the front passenger system; Figure 3-2 shows the system's location in the dash. (The inflator module was produced for Volvo by Eaton Safety Systems.)

The sheetmetal module box (Figure 3-3) contains a stored gas inflator and an unvented coated nylon airbag. Slots cover the box's top, bottom and sides. During inflation these slots perform two functions: initially, they permit additional air to flow into the bag (aspiration); later they act as vents, thus providing a method of force limitation.

The front passenger knee restraint, like the driver knee restraint, is a deforming sheetmetal reaction plate covered by 2 inch thick rigid foam and a black plastic fascia. Both the knee restraint and the module box attach to a crossmember located below the dash.

3.2 SECOND VOLVO BARRIER TEST (TEST 1555)

Preparation

Test 1555 was the initial 40 mph vehicle test of the passenger airbag restraint system. The stock module (with its stored gas inflator) was replaced with a ganged system of two 123 gram Talley driver inflators. An 18 gauge sheetmetal module box (which mounts the inflators and airbag) was fabricated to fit into the dash space used by the stock Eaton module. The coated nylon airbag has a volume of approximately 5 cubic feet and a 2 inch diameter vent. The modified airbag

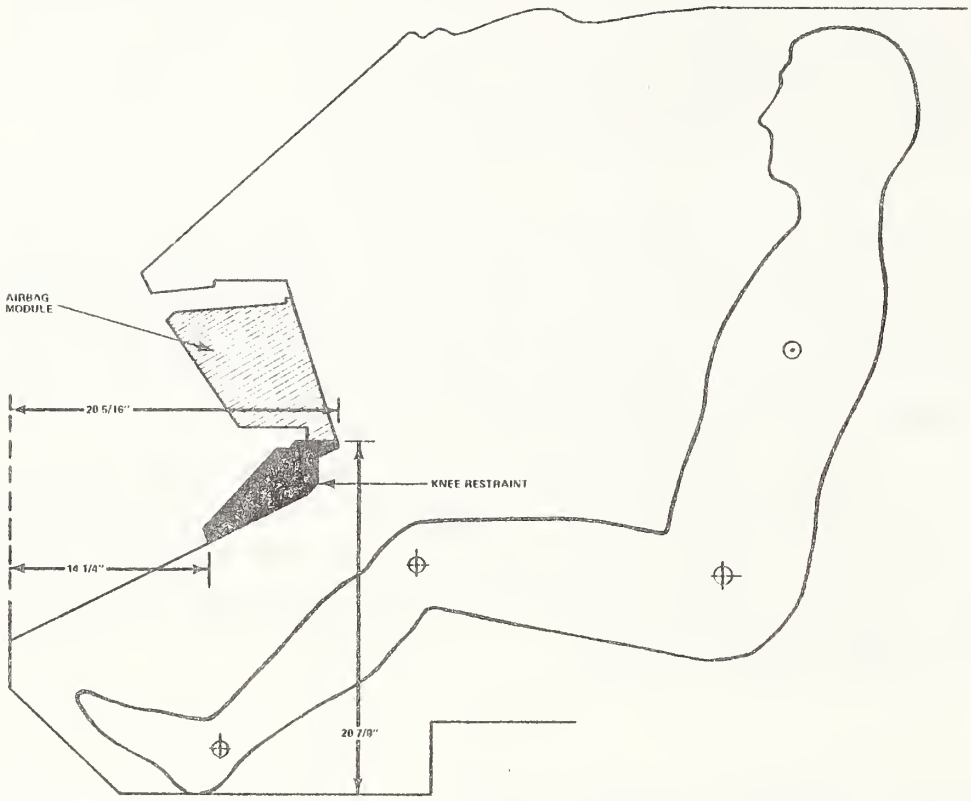


FIGURE 3-1. VOLVO PASSENGER RESTRAINT GEOMETRY

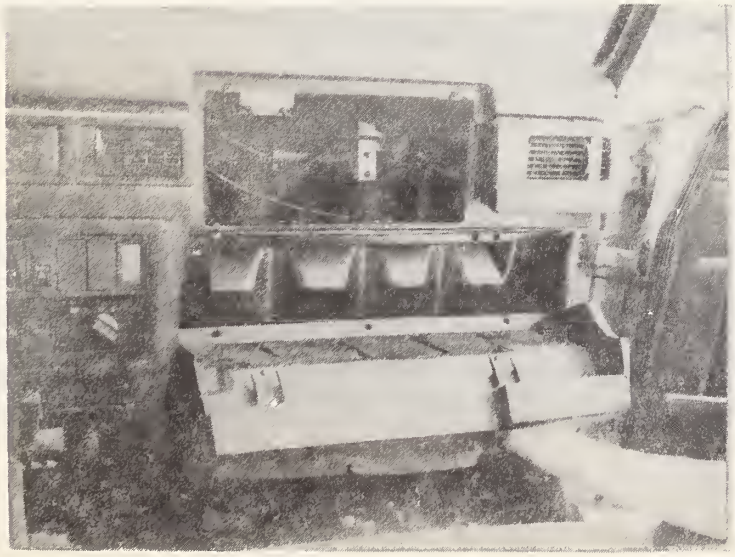


FIGURE 3-2. PASSENGER STATION INTERIOR

FIGURE 3-3. VOLVO 244 PASSENGER AIRBAG SYSTEM

system is shown in Figure 3-4. The knee restraint remained stock for this exploratory barrier test.

Results

The test did not give meaningful results because one of the two driver inflators had not been connected to the squib current. The single inflator only partially filled the bag, so the passenger bottomed out against the dash and windshield. The results of all of the passenger tests are summarized in Table 3-1.

FIGURE 3-4. MODIFIED PASSENGER AIRBAG SYSTEM

TABLE 3-1. PASSENGER SYSTEM TESTS

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds)		See Note
							Left	Right	
1555 (Barrier)	Initial passenger test. Talley 123g ganged driver inflator.	40.5	2 inch vent diameter	Stock	1900	150	2400	1400	1
1568 (Barrier)	Thiokol 380g inflator used.	40.2	3-1/8 inch vent diameter	Stock	450	65	1800	1900	2
1585 (Sled)	Same system as 1568 but with 420g inflator for faster deployment.	40.5	3-1/8 inch vent. Thiokol 420g of 0.120 inch by 1/4 inch pellets.	Stock	1122	76	NA	1250	3
1591 (Sled)	Installed pivoting knee restraint with plastic hinge EAs. Seat was reinforced because it bent in previous test.	39.4	Same as Test 1585.	Pivoting with 2 1700 pound EAs.	1221	85	2400	2600	4
1606 (Sled)	Pivoting knee restraint removed and stock restraint (with 3 inch deeper foam – for a total of 5.2 in) installed to allow more knee stroke. Seat not reinforced.	40.4	Bag made 4 inches narrower. Same vent and inflator as Test 1591.	Stock type with 3 inch deeper foam.	1820	120	1500	2400	5

NOTES:

1. One of the two driver inflators was not connected – passenger bottomed bag.
2. Thiokol inflator used because Talley inflators were unavailable in time for test.
3. The knee restraint pivoted about its crossbar, allowing the passenger to submarine.
4. Knee stroke was insufficient, causing passenger to pitch into bag. Reinforced seat probably caused excessive (27 Gs) chest S-I acceleration.
5. Insufficient ridedown because of slow bag deployment. Chest acceleration began at 65 msec. Knee restraint reaction plate needs reinforcement to reduce yielding.

TABLE 3-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds) Left	Femur Loads (pounds) Right	See Note
1612 (Sled)	Faster 420g inflator load, shorter bag, and shallower module pan installed to reduce volume and speed bag deployment.	41.0	Thiokol 420g with 260g of 0.120 inch by 1/4 inch and 160g of 0.060 inch by 1/4 inch pellets. 2 inch shorter bag.	Same as previous but with hat reinforcement on reaction plate.	1074	75	1800	1800	6
1619 (Sled)	Bag vent size increased to 3-7/8 in diameter to reduce dummy rebound. Squib delay decreased to a more reasonable 8.6 msec.	40.2	3-7/8 inch vent. Same bag shape and inflator as Test 1612.	Same as previous.	412	67	1700	1800	7
1626 (Sled)	Deeper knee restraint with yielding lower attachment installed to allow more knee stroke.	39	Same as previous test (1519).	1-1/2 inches deeper foam (total 6.7").	162	71	1300	1750	8
1632 (Sled)	Deeper knee restraint installed. Bag volume reduced.	40.2	Slightly shorter bag. Same inflator and vent.	9.5 inch deep knee restraint.	365	44	1360	1550	9
1639 (Sled)	Thiokol 380g inflator used. Bag vent location moved.	39.7	Bag vent moved to a point between dash and windshield.	Same as previous test (1632).	705	68	1400	1450	10
1645 (Sled)	Bag vent size reduced from 3-7/8 to 3-1/2 inches because the inflator is smaller. Vent location moved to side to avoid escape of gas.	41.1	Bag vent 3.5 inch diameter; relocated back to side panel.	Same as previous test (1639).	789	72	1600	1650	11

NOTES:

6. The bag deployed faster; chest acceleration began at 50 msec. Dummy rebound was excessive.
7. Dummy rebound was reduced, but insufficient knee stroke pitched the dummy into the bag.
8. Knee restraint still did not allow sufficient knee stroke.
9. Good test results.
10. Vent location allowed gas to escape directly through vent, reducing amount of available gas.
11. Insufficient ridedown caused high chest acceleration.

TABLE 3-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds)		See Note
							Left	Right	
1655 (Sled)	Intrusion independent restraints mounting crossmember installed. Knee restraint changed to attach to new crossmember. Bag, vent and inflator same as Test 1632.	40.4	Vent made 3-7/8 inch diameter, 420g Thiokol as in 1632. Diffuser slots aimed at 0 degrees instead of 8????	Upper reaction surface raised to reach new cross-member. Other-wise, same geometry.	521	46	1950	600	12
1663 (Sled)	Shorter knee restraint to keep dummy on seat.	40.4	Same as previous test (1655).	Knee restraint shorter by 2.4 inches on top; same depth at bottom.	801	65	1900	800	13
1676 (Sled)	Same knee restraint as Test 1632 with attachment to new crossmember to keep dummy on seat and still have sufficient depth.	40.8	Same as previous test (1655).	Same as 1632 with new attachment.	595	62	1600	1600	14
1681 (Sled)	Repeat of Test 1655 with new seat and reinforced (non-yielding) crossmember.	41.0	Same as previous test (1655).	Increased in height to 1655 dimensions.	454	56	900	1200	15
1697 (Barrier)	Same restraint system as Test 1655 but with the stock dash. Seat moved one notch (1/2 inch) forward to mid position.	40.2	Same as Test 1655.	Same as 1655.	243	57	1500	No Data	16

NOTES:

12. Higher knee restraint reaction surface allowed passenger to slide off the front edge of the seat. Nevertheless, the test results were good.
13. Shorter knee restraint pitched dummy into bag – dummy slid off seat.
14. Seat bent down, failing to guide dummy into KR, and left knee contacted top edge of KR – knees penetrated foam only halfway – dummy slid off seat.
15. Reinforced crossmember did not yield – may have caused high chest acceleration. Dummy slid off seat. Injury measurements were below FMVSS 208 criteria.
16. Good results, except for high chest acceleration. Injury measurements were below FMVSS 208 criteria. The dummy stayed on the seat in this test.

TABLE 3-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds) Left	Femur Loads (pounds) Right	See Note
1713 (Barrier)	Same as previous test (1697) except for an increase in vent size to use all available stroking distance. Knee restraint moved toward passenger 1/2 inch to more closely correspond to stock.	40.2	Same as Test 1697 except vent increased from 3-7/8 to 4-1/8 inch diameter.	Same, but 1/2 inch closer.	505	44	No Data	1850	17
1718 (Barrier)	Vehicle barrier test. Same as previous test but intrusion independent restraints mounting crossmember modified to clear heater system.	40.0	Same	Same	206	45	2200	1400	18
1735 (Sled)	First 30 mph sled test (low level system). 380g inflator. The rest of the system identical to that in Test 1655.	30.5	Same bag as 1718. 380 grams of 1/4 inch by 0.120 inch pellets.	Same as Test 1655.	100	37	800	700	19
1737 (Sled)	First standing 3-year-old test at 30 mph. Same system as 1735.	31.0	Same	Same	307	57/47	-	-	20
1741 (Sled)	Same as 1737 with less tape holding dummy in position.	30.3	Same	Same	278	10	-	-	21
1855 (Sled)	3-year-old standing child test at 12 mph. Thiokol 342g of 1/4 inch by 0.120 inch pellets. Otherwise same as Test 1735.	15.0	Same as 1735 except 342g inflator.	Same	75	67/30	-	-	22

NOTES:

17. Good results. Dummy stayed on seat.
18. Good results.
19. Good results.
20. Bagslap slightly high. Also, tape holding child in position was too secure, causing excessive chest SI.
21. Meaningless data, dummy fell out of position due to insufficient tape.
22. High bagslap.

TABLE 3-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds)		See Note
							Left	Right	
1862 (Sled)	Standing 3-year-old test at 12 mph. Thiokol 342g of 1/4 inch by 0.135 inch pellets (slower). Otherwise same as Test 1735.	30.0	Same as 1735 but 324g of 1/4 inch by 0.135 inch pellets.	Same	98	38/32	-	-	23
1864 (Sled)	50th test at 30 mph: low level system. Same as Test 1862.	30.7	Same as 1862.	Same	287	45	780	500	24
1872 (Sled)	First test of high level system with 50th at 40 mph. Otherwise same as Test 1862.	38.0	Same as 1862 plus booster inflators. Thiokol 104g mixed load.	Same	605	60	800	1450	25
1888 (Sled)	Same as Test 1872 but faster booster inflator. Thiokol 100g of 1/4 inch by 0.075 inch pellets.	40.5	Same as 1872 except booster is 100g of 1/4 inch by 0.075 inch pellets.	Same	673	61	680	1920	26
1893 (Sled)	Same as Test 1872 but still faster booster inflator. Thiokol 100g of 1/4 inch by 0.060 inch pellets.	40.4	Same as 1872 except booster is 100g of 1/4 inch by 0.060 inch pellets.	Same	458	51	700	1160	27
1895 (Sled)	Same as 1862. Standing 3-year-old at 12 mph but with bag cover.	13.3	Same as 1862. 342g of 1/4 inch by 0.135 inch pellets.	Same	90	31/17	-	-	28

NOTES:

23. Good results. Slower inflator reduced bagslap.
24. Good results.
25. Slow bag inflation caused insufficient ridedown.
26. Slow bag inflation caused insufficient ridedown.
27. Good results.
28. Good results. Bag cover improved results over Test 1862.

TABLE 3-1. (Cont'd)

Test	Changes Since Last Test	Speed (mph)	Air Bag & Inflator	Knee Restraint	HIC	Chest Acceleration & Bagslap/Catapult (Gs - 3 msec duration)	Femur Loads (pounds)		See Note
							Left	Right	
1899 (Sled)	50th at 30 mph with bag cover. Otherwise same as Test 1864 (low level).	30.8	One inflator.	Same	450	48	670	920	29
1902 (Sled)	50th at 40 mph. High level (two inflators) with bag cover. Otherwise same as Test 1893.	40.3	342g of 1/4 inch by 0.135 inch; 100g of 1/4 inch by 0.060 inch pellets.	Same	413	51.6	720	1195	30
1909 (Sled)	5th female at 33 mph. High level with bag cover.	33.2	Same as previous (1902).	Same	166	29	760	740	31
1911 (Sled)	95th at 33 mph. High level with bag cover.	33.5	Same as previous (1902).	Same	377	43	1120	1350	32
1969 (Barrier)	40 mph, 50th, barrier test dual level system in high level. Same as sled test 1902.	40.25	Same as Test 1902.	Same	264	50.4	1580	1580	33

NOTES:

29. Good results.
30. Good results (same results as Test 1893).
31. Good results.
32. Good results.
33. Good test, excellent results – all measurements below criteria.

3.3 THIRD VOLVO BARRIER TEST (TEST 1568)

Preparation

The passenger system in this barrier test was originally intended to be identical to that in Test 1555. However, during the preparation of the car we were informed that the inflators would not be delivered in time for the test, so we decided to use a single 380 gram Thiokol 14 inch passenger inflator. We chose a 3-1/8 inch diameter airbag vent on the basis of a computer simulation, and we enlarged the module pan to accommodate the longer inflator. The system otherwise remained the same as it was in Test 1555.

Results

All injury measurements except chest acceleration were within the FMVSS 208 criteria. The chest acceleration exceeded the criteria (by 5 Gs) because the pressure did not build early enough in the bag (i.e., there was insufficient ridedown).

3.4 PASSENGER RESTRAINT SYSTEM SLED TESTS

The initial sled test of this series (Test 1585) used the same system as Test 1568, except that the inflator load was increased from 380 to 420 grams. During Sled Tests 1591, 1606, 1612, 1619, 1626 and 1632 a number of changes were made to tune the system to protect the 50th percentile male dummy at 40 mph. The stock knee restraint was replaced by a deeper energy absorbing foam knee restraint (which was made progressively deeper during the tests in order to reduce the pitching trajectory of the dummy); a portion of the inflator load was changed to smaller, faster burning pellets; the airbag volume was reduced slightly; and the bag shape was improved. These modifications increased the dummy's ridedown – and, therefore, further reduced the chest acceleration. We also enlarged the airbag vent from 3-1/8 to 3-7/8 inches in diameter (to make full use of the available stroking distance and to reduce rebound) and increased the depth of the foam in the knee restraint to 8-1/2 inches.

Test 1632 produced good injury measurements. The chest acceleration was 44 Gs and all other measurements were well within the FMVSS 208 criteria.

We next ran two sled tests (Tests 1639 and 1645) to investigate the capabilities of the Thiokol 380 gram passenger inflator. In both tests slow bag inflation (resulting in insufficient ridedown) caused excessive chest acceleration. It was decided that the 380 gram inflator simply did not produce enough gas.

It was at this point that the more production oriented steering column mount was designed. The mount is a sheetmetal box section attached between the two A-pillars. This new crossmember required modifications to the passenger knee restraint and the module box mount. The knee restraint geometry remained the same, but additional foam was needed to fill the space between the front surface and the higher crossmember.

Sled Tests 1655, 1663, 1676 and 1681 were conducted with this intrusion independent restraints mounting crossmember, the 420 gram inflator and the 3-7/8 inch diameter vent. The tests were primarily conducted to evaluate changes in the knee restraint. The 8-1/2 inch deep knee restraint chosen for the fourth Volvo barrier test was the same design as was used in Tests 1655 and 1681. The results of Test 1655 were good; all of the passenger's injury numbers were below the FMVSS 208 criteria.

3.5 FOURTH VOLVO BARRIER TEST (TEST 1697)

Preparation

The passenger restraint system in Test 1697 was the same as that used in Sled Test 1655. The system had a 420 gram mixed load inflator, a 3-7/8 inch airbag vent and a 8-1/2 inch deep knee restraint.

Results

All of the injury measurements were below the FMVSS 208 criteria. The chest acceleration was slightly high (57 Gs), but measurements taken from the high speed films indicated that at full bag penetration there were still 4 inches between the dummy's chest and the dash. In light of this, the vent size for the next barrier test was increased to allow more stroking distance and lower chest acceleration.

3.6 FIFTH VOLVO BARRIER TEST (TEST 1713)

Preparation

The passenger restraint system in Test 1713 was the same as in Test 1697, except for the increase in vent size (from 3-7/8 to 4-1/8 inches in diameter). The only other change was the removal of the heater unit (as described in Subsection 2.7).

Results

All of the injury measurements were well below the FMVSS 208 criteria. The chest acceleration was 44 Gs, which corresponded closely with the results obtained during sled testing.

3.7 SIXTH VOLVO BARRIER TEST (TEST 1718)

Preparation

The only change affecting the passenger system was a modification of the restraints mounting crossmember. The crossmember was redesigned to clear the heater unit, so that the heater could be included in this test. The remainder of the passenger restraint system remained the same as that in Test 1713.

Results

All of the injury measurements were within the FMVSS 208 injury criteria and corresponded closely with those of the previous test.

3.8 CONTRACT MODIFICATION TO DEVELOP A DUAL LEVEL PASSENGER SYSTEM

Preparation

The passenger airbag restraint system developed up to this point in the program was tuned to protect the 50th percentile male dummy at 40 mph. To obtain this level of protection we used an inflator with a relatively fast gas flow rate onset. This inflator pressurizes the airbag quickly, so that the dummy is restrained early in the event and therefore has the ridedown necessary for acceptable chest acceleration measurements. The drawback with the fast inflator is the excessive chest acceleration measurements it produces on a forward positioned 3-year-old child dummy. With the dummy in a standing position, it is located directly in front of the inflator and therefore in the path of the deploying airbag).

One method of protecting both the 50th percentile passenger at 40 mph and the out-of-position 3-year-old is to install a dual level inflation system. The dual level system has two inflators: the main inflator is fired at any speed above the threshold of 12 mph; the booster inflator only at speeds above 30 mph. The low level portion of this system (main inflator only) is tuned to protect both the 50th percentile male up to 30 mph and the standing 3-year-old child at the threshold deployment speed of 12 mph. The high level portion of the system (main inflator plus booster inflator) is tuned to protect the 50th percentile male in the much more severe 40 mph barrier crash. The great advantage of the system is that a relatively slow main inflator can provide reasonable protection for both the standing child at 12 mph and for (at least adequate protection of) the adult at 30 mph. A smaller, fast onset booster inflator then provides the quick pressurization of the bag necessary for protecting the 50th percentile male at 40 mph.

The chest acceleration of the standing 3-year-old child during bag deployment has two distinct phases: the first (called "bagslap") is typically the initial spike that occurs when the mass of the folded bag strikes the chest of the dummy; the second (the "catapult") occurs after the bag has contacted the dummy and has begun to pressurize and accelerate the dummy rearward. The relative acceleration levels of each phase are important in tuning the system. An inflator with a fast onset will cause high bagslap accelerations and an inflator with a large gas capacity will produce high catapult accelerations. The passenger data summary in Table 3-1 lists the peak bagslap and catapult accelerations of each 3-year-old child sled test*.

In all of these tests the airbag was stored by first folding in the side panels and then rolling the bag under. This causes the bag to roll downward as it inflates against the chest of the standing child. To allow the downward deployment, the rolled airbag is stored outside the front surface of the module box.

Sled Testing

The first sled tests in this series (Tests 1735, 1737, 1741, 1855, 1862 and 1864) were conducted to tune the low level system (main inflator only) to protect both the standing 3-year-old child at 12 mph and the 50th percentile male at 30 mph. These tests began with a 380 gram Thiokol 14 inch passenger inflator. In Test 1855 this load was reduced to 342 grams and the propellant pellet size was increased from 1/4 x 0.120 to 1/4 x 0.35 inch to slow the flow rate onset. These changes were necessary to reduce the 3-year-old child's injury measurements to below the FMVSS 208 criteria for adults.

These levels were achieved in Test 1862 (bagslap 38 Gs, catapult 32 Gs). The inflator was then tested at 30 mph with a 50th percentile male dummy (Test 1864), and all of the injury measurements were within the FMVSS 208 criteria.

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*Because of the lack of criteria specific to children, the FMVSS 208 criteria for adults were used to evaluate the performance of the restraint system with the standing 3-year-old child.

Sled tests 1872, 1888 and 1893 were conducted to tune the high level system to protect the 50th percentile dummy at 40 mph. This was done by increasing the speed of the booster inflator until the airbag inflated fast enough to afford sufficient ridedown. In Test 1893 all of the injury levels on the 50th percentile male dummy at 40 mph were well below the FMVSS 208 criteria. In that test a Thiokol lightweight driver inflator loaded with 100 grams of 1/4 x 0.060 inch pellets was used as the booster inflator.

The three following sled tests (Tests 1895, 1899 and 1902) employed an airbag cover. These tests evaluated the low level system at 12 mph with the 3-year-old child, the low level system at 30 mph with the 50th percentile male, and the high level system at 40 mph with the 50th percentile male. In each of these tests the bag cover had very little effect on the results. In the 3-year-old child test the results were actually improved with the bag cover.

The final two sled tests (Tests 1909 and 1911) evaluated the high level system (including the bag cover) at 33 mph with the 5th percentile female and the 95th percentile male. In both of these tests all of the injury measurements were below the FMVSS 208 criteria.

3.9 SEVENTH VOLVO BARRIER TEST (TEST 1969)

Preparation

Test 1969 was the final test of the dual level system under this contract. The system has the following components. The module box and the knee restraint are both mounted on the intrusion independent restraints mounting crossmember (Figures 3-5 and 3-6). The module box, which is made of 18 gauge steel, contains both of the inflators and the airbag. The low level inflator is a 14 inch Thiokol passenger unit loaded with 342 grams of 1/4 x 0.135 inch pellets. The booster is a Thiokol lightweight driver inflator loaded with 100 grams of 1/4 x 0.060 inch pellets. The coated nylon airbag, which is attached to the module box, has a (approximate) 4-1/2 cubic foot volume and a 4-1/8 inch diameter vent. This is all covered by a semi-rigid 0.050 inch Thiokol polyethelene

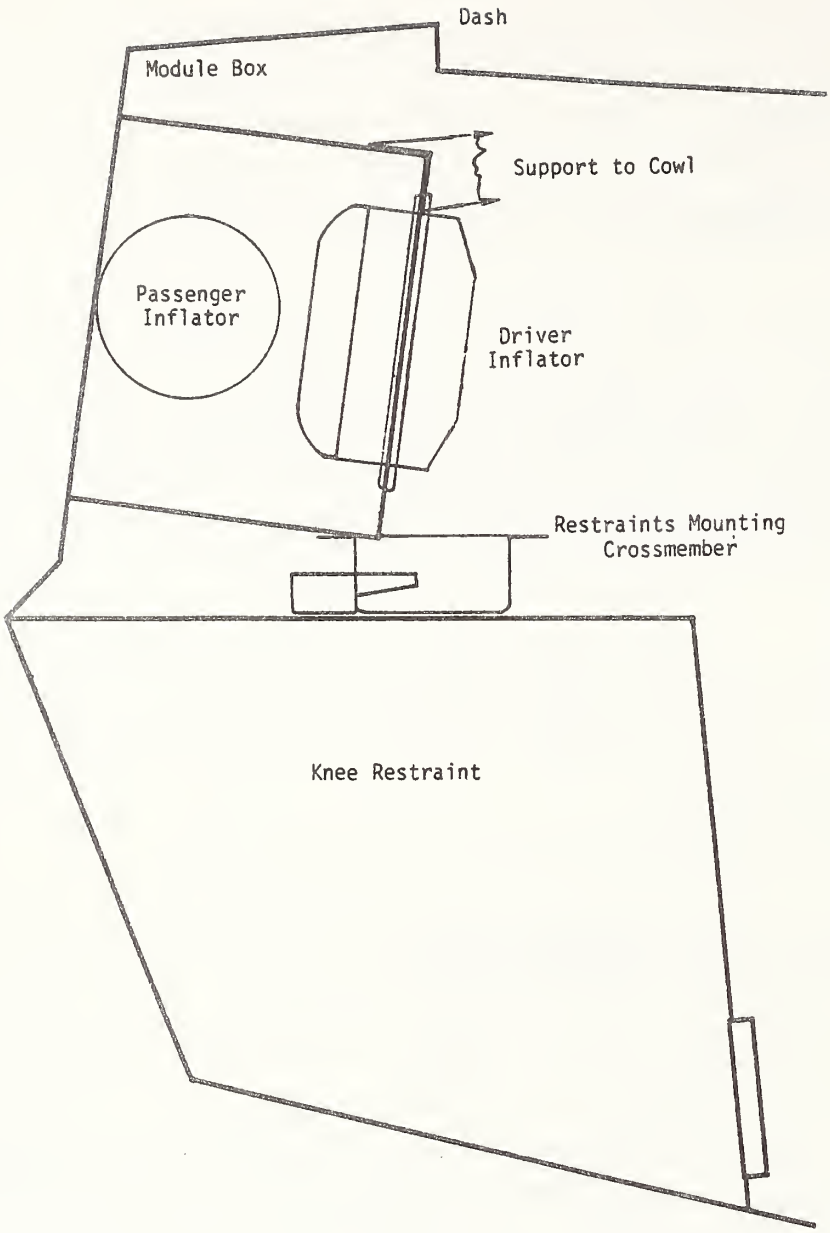


FIGURE 3-5. PASSENGER RESTRAINT LAYOUT

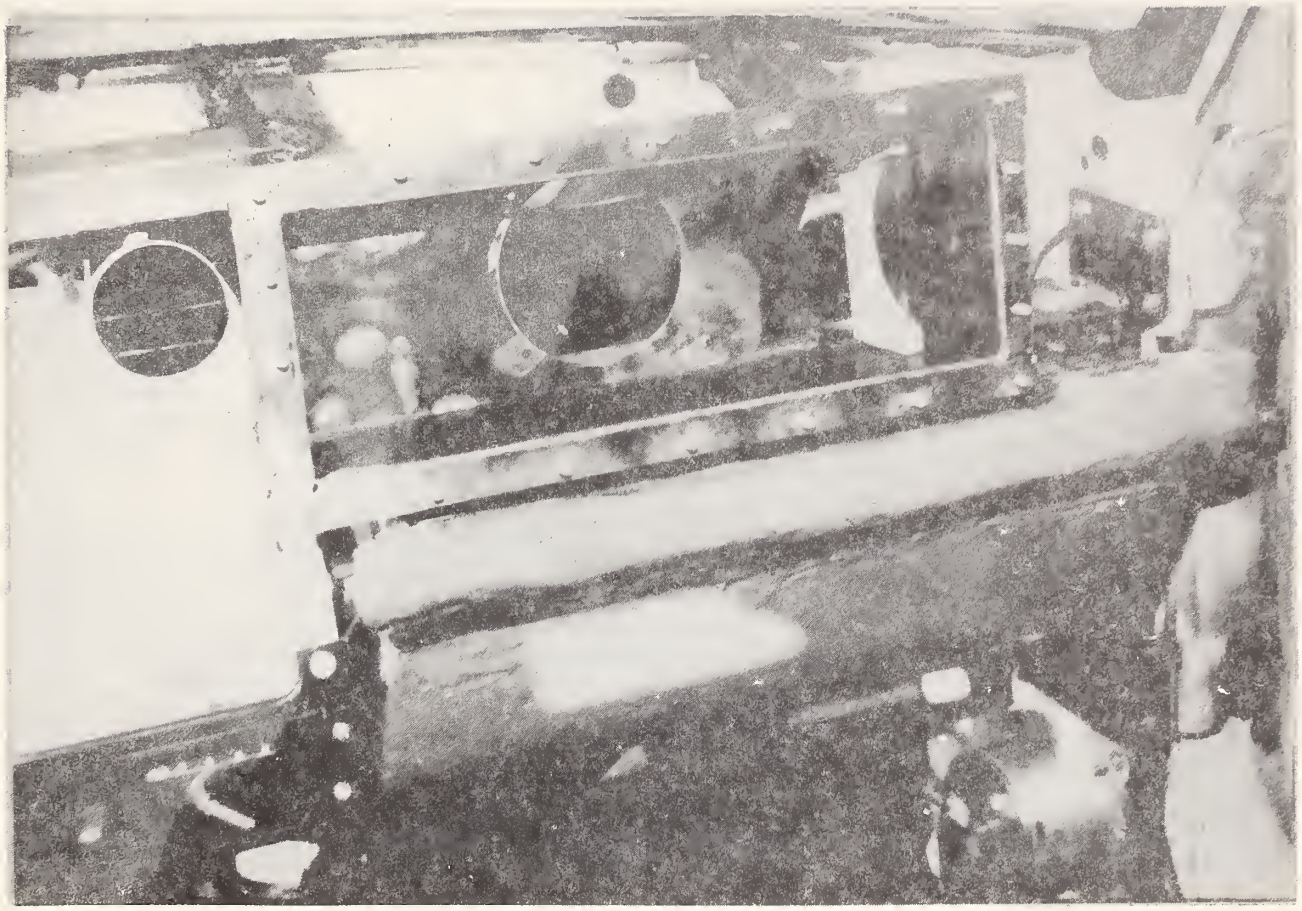


FIGURE 3-6. PASSENGER RESTRAINT MODULE BOX

plastic sheet perforated to allow the bag to deploy and a black vinyl exterior that matches the surface to the dashboard.

The knee restraint is 8-1/2 inches of deep rigid foam (Stathane 6502) backed by an 18 gauge steel reaction plate which is reinforced with a hat section. The foam is coated with a soft plastic material (called "Uralite"). The top of the knee restraint attaches beneath the crossmember, and the lower edge is mounted (via steel straps) to the A-pillar on the right side and to an upright bracket from the tunnel on the left side. Figure 3-7 shows the mounted knee restraint, and Figure 3-8 the completed passenger station.

Results

The results of this 40 mph test were excellent. All of the 50th percentile male dummy's injury measurements were well below the FMVSS 208 criteria. The high level system performed exactly as it did during sled testing. The results correlated closely with those of the single level passenger system in the previous barrier tests at 40 mph.

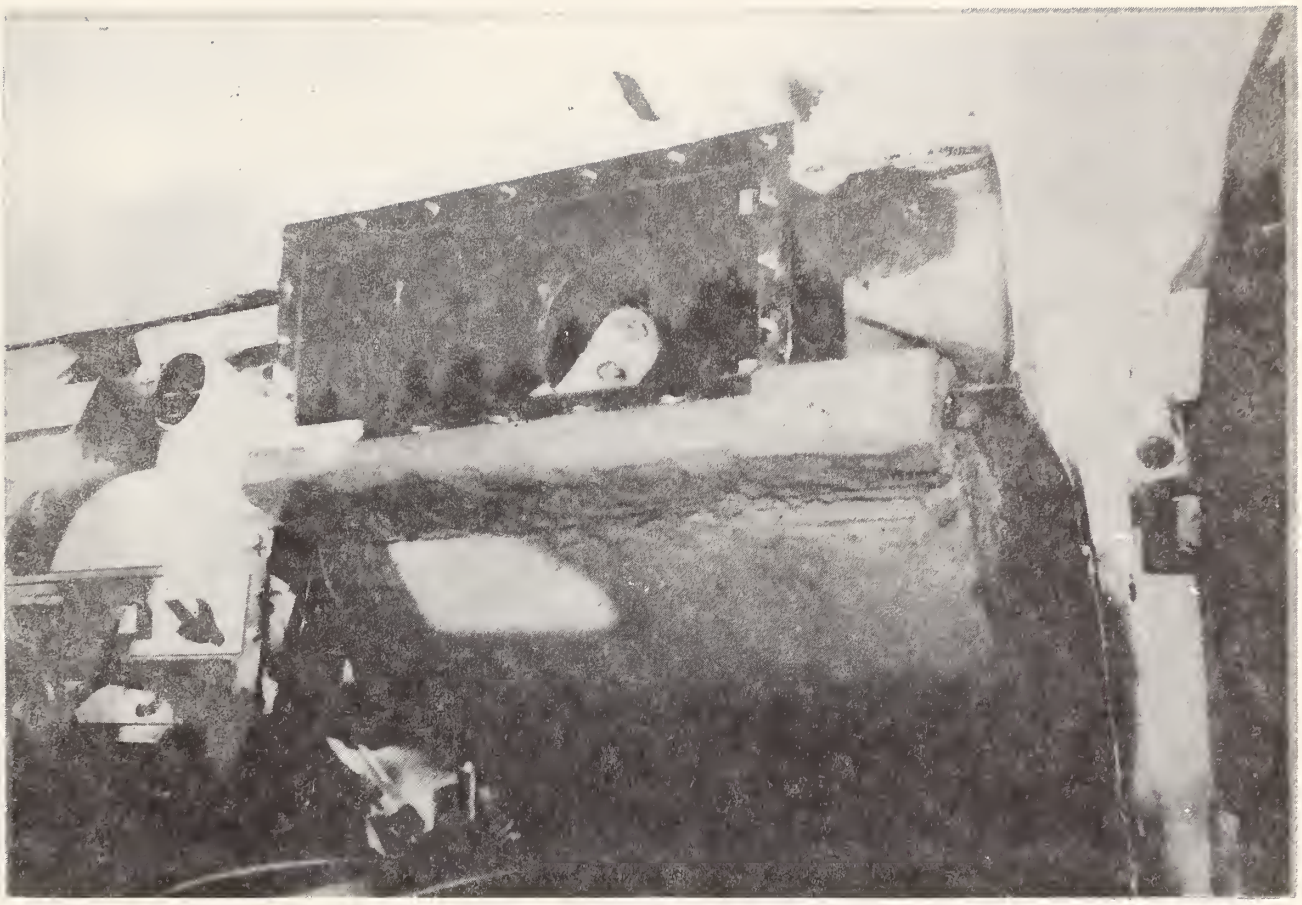


FIGURE 3-7. PASSENGER KNEE RESTRAINT

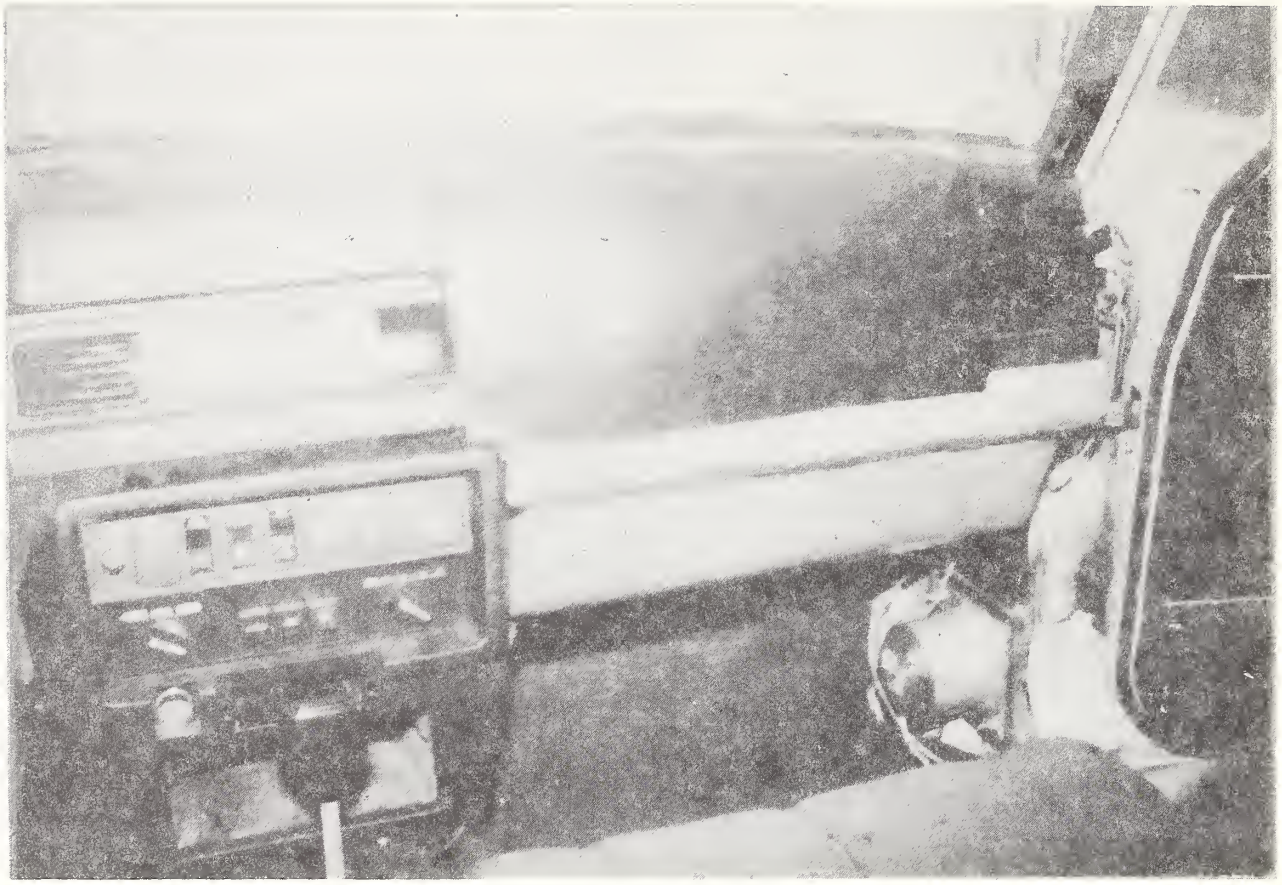


FIGURE 3-8. INSTALLED PASSENGER RESTRAINT SYSTEM

SECTION 4

CONTRACT MODIFICATION TO DEVELOP AN UPGRADED SEAT BELT SYSTEM FOR THE 1979 VOLVO

4.1 INTRODUCTION

In the NHTSA's New Car Assessment Program (NCAP) a 4-door Volvo was crash tested at 35 mph by Mobility Systems, Los Angeles, California. Head strikes on the steering wheel and dashboard in that test caused the dummies' HIC measurements to fail the FMVSS 208 criteria. Consequently, the present contract was modified to include the upgrade of two Volvo seat belt systems – the production systems installed in the 1979 244DL (4-door sedan) and 242DL (2-door sedan). The goal of this project was to provide satisfactory protection of the front seat occupants in a 35 mph barrier crash.

Ten sled tests and two vehicle barrier tests were conducted under this contract modification. In the first five sled tests we attempted to duplicate the results of the NCAP crash test and to determine the performance differences between the 4-door and 2-door systems. The remaining five sled tests evaluated various modifications. Each sled test was conducted with both driver and passenger dummies. Finally, the two barrier tests evaluated the performance of the upgraded belt system in the 4-door 244DL and in the 2-door 242DL.

The data traces for all of the tests conducted under this modification are contained in the appendix. Table 4-1 summarizes the verification sled tests, Table 4-2 the evaluation tests, and Table 4-3 the vehicle barrier tests.

4.2 VERIFICATION SLED TESTS

The verification sled tests included four stock 4-door system tests and one stock 2-door system test (for comparison). The HIC measurements in three of the 4-door system tests (Tests 1959, 1962 and 1964) averaged about 1300 for both the driver and the passenger. Even through these high measurements were produced by head strikes on the steering wheel and dashboard, they were significantly lower than

TABLE 4-1. VERIFICATION BELT SYSTEM SLED TESTS

Test Description	Driver System							Passenger System							
	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact Severity	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact or Distance From Dash	Belt Spool-Out (inches)
			Left	Right	Torso	Lap				Left	Right	Torso	Lap		
Test 1956 Speed: 34.5 mph Belt System: Stock 4-door (seat 1-1/2 inches forward of all following tests)	715	39.0	NA	NA	1725	1017	Light	1081	45.7	321	408	NA	NA	1 inch	3-3/4
Test 1959 Speed: 35.8 mph Belt System: Stock 4-door	1090	42.5	NA	NA	1927	1316	Medium	1332	48.0	316	411	NA	NA	Wiped	4-3/4
Test 1962 Speed: 36.4 mph Belt System: Stock 4-door. Repeat of Test 1959	1491	47.7	405	NA	1951	1701	Heavy	1549	52.5	404	359	NA	1504	Wiped	5
Test 1964 Speed: 36.9 mph Belt System: Stock 4-door. Repeat of Tests 1959 and 1962	1274	63.0	308	341	2064	1314	Heavy	1202	52.6	351	435	1900	1488	Wiped	5
Test 1965 Speed: 36.3 mph Belt System: Stock 2-door	617	36.3	559	322	1702	1647	Barely Touched	816	41.1	333	370	1809	1304	3-1/2 inches	2-1/2

TABLE 4-2. MODIFIED BELT SYSTEM SLED TESTS

Test Description	Driver System							Passenger System							
	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact Severity	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact or Distance From Dash	Belt Spool-Out (inches)
			Left	Right	Torso	Lap				Left	Right	Torso	Lap		
Test 1972 Speed: 36.7 mph Belt Systems: 4-door/ shortened 12 inches	779	38.1	469	387	1796	1455	Light	614	41.8	327	391	1830	1264	2 inches	2
Test 1973 Speed: 35.9 mph Belt Systems: 4-door/ shortened 6 inches	850	39.8	295	276	1770	1419	Medium Light	1691	96.6	2231	1452	NA	1340[2]	Light	3-1/2
Test 1974 Speed: 35.1 mph Belt Systems: 4-door/ Irvin web lock	951	45.2	429	311	2207	1530	Medium	920	43.2	413	388	2160	1463	2 inches	1
Test 1977 Speed: 36.5 mph Belt Systems: Driver - 4-door/Irvin web lock (no wheel or column) Passenger - 4-door/shortened 6 inches	1113	59.2	484	449	2215[1]	1604	Heavy	834	40.8	368	435	1999[3]	1441	Medium	4
Test 1980 Speed: 36.3 mph Belt Systems: Driver - 4-door/Irvin web lock (no wheel or column) Passenger - 4-door/shortened 6 inches	536	60.0	323	372	2084[1]	1441	Heavy	813	47.0	556	374	2077	1314	1 inch	4

NOTES:

1. Belt tore at web lock, then buckle pulled out of latch.
2. Lap belt cut by sharp edge protruding from used seat.
3. Torso belt tore at D-ring.

TABLE 4-3. VEHICLE BELT SYSTEM TESTS

Test Description	Driver System							Passenger System							
	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact Severity	HIC	Chest Acceleration (Gs - 3msec)	Femur Loads (pounds)		Belt Loads (pounds)		Head Impact or Distance From Dash	Belt Spool-Out (inches)
			Left	Right	Torso	Lap				Left	Right	Torso	Lap		
Test 1981 Speed: 36.1 mph Belt Systems: 4-door/ shortened 8 inches	703	50.0	284	1329	1536	1375	Medium	956 [1]	56	480	376	1562	1334	Heavy	NA
Test 1982 Speed: 35.5 mph Belt Systems: 2-door/ shortened 8 inches	499	41.2	343	960	1373	1129	Light	539	34.8	609	301	1371	1000	No Head Strike	NA

NOTE:

1. Result of dash intrusion and excess speed.

the ones obtained in the NCAP crash test (driver HIC 1782, passenger HIC 1889). On the other hand, the numbers obtained in these sled tests were higher than those measured in a series of barrier tests conducted by Volvo after the NCAP test. The fifth test, which was conducted with the 2-door (relocated B-pillar) seat belt system, produced injury numbers significantly lower than did the tests with the 4-door system.

4.3 EVALUATION SLED TESTS

Five sled tests (Tests 1972, 1973, 1974, 1977 and 1980) were then conducted to evaluate modified 4-door seat belt systems. Three modifications were tested on both the driver and the passenger: shortening the total belt webbing length by 12 inches, shortening the webbing length by 6 inches, and replacing the stock D-ring with a web locking device. The web lock (the "Snubber", designed and manufactured by Irvin Industries, Inc., Madison Heights, Michigan) allows the belt to move freely under normal use but locks it under the higher belt loads experienced in a crash.

Our inspection of the stock 4-door Volvo seat belt system indicated that shortening the webbing length by up to 12 inches would not adversely affect the convenience of various sized occupants in reasonable seating positions. Shortening the belt reduces the amount of webbing remaining on the retractor, therefore reducing the amount that can spool out. The results of the sled tests using shortened belts showed less spool out and less occupant translation. By reducing or eliminating the head strikes, this modification lowered the injury measurements to well within the FMVSS 208 criteria.

In one of these shortened belt tests (Test 1977 for the passenger) the belt tore at the D-ring. Inspection of the webbing showed evidence of creases and burning where the belt was bunching up as it was pulled through the ring. In the following test (Test 1980) we focused a high speed camera on the D-ring; the film showed that there was an instability which allowed the ring to suddenly change its angle at the peak belt load and cause the belt to bunch up. Evidence of creases and burning were seen in almost every test that used this D-ring, and it

was more severe in tests in which the test speed was slightly high. To solve this problem, the D-ring would have to be redesigned.

The web locking device, which replaces the D-ring, locked the belt quickly and showed little or no spool out. This reduced the injury measurements (Test 1974), although they were not as low as with the shortened belts. However, in two of the four tests (Tests 1977 and 1980 for the driver) with the web lock, the webbing tore at the lock. The tearing was caused by localized stress over an edge near the point at which the torso belt first passes through the lock. In both tests in which the belt tore, the seat belt latch then failed to hold the buckle (because of the increased loading). This is a possible deficiency in the Volvo buckle-latch mechanism. Another problem with the web locks is a matter of convenience; there is too much friction as the belt moves through the lock. This causes the device to lock too easily in normal use and prevents the retractor from reliably reeling in the belt to remove slack.

We decided to test 8 inch shorter belts in both the 4-door and 2-door Volvo barrier tests. This length is a compromise between the 6 inch and 12 inch shorter belts evaluated during sled testing.

4.4 BARRIER TESTS

Test 1981

Test 1981 was a 35 mph barrier test of a stock 1979 Volvo 244DL. Both the driver and passenger seat belt systems were brand new 4-door belts shortened 8 inches. Even though the actual test speed was slightly high (36.1 mph), and the dummies' heads struck the upper steering wheel rim and the dashboard (driver and passenger, respectively), all of the injury measurements were below the FMVSS 208 criteria. The passenger's HIC was higher than the measurements obtained in sled testing, for two reasons: the test speed was slightly high, and the dash intruded 2 to 3 inches, causing a more severe head strike.

Test 1982

Test 1982 was another 35 mph barrier test, this time with a stock 1979 Volvo 242DL. The seat belts were brand new 2-door belts shortened 8 inches. The actual test speed was 35.5 mph. The results were excellent. All the injury measurements on both the driver and passenger were well below the FMVSS 208 criteria. The driver sustained only a mild head strike on the upper steering wheel rim, and the passenger had no head strike.

SECTION 5
PROGRAM SUMMARY

In this contract a modified Volvo air cushion restraint system provided full frontal 40 mph BEV protection for two 50th percentile male front seat occupants of a Volvo sedan. These production oriented modifications were developed in sled tests and confirmed in actual vehicle barrier impacts (in which the test dummies sustained acceleration levels significantly below those of the FMVSS 208 requirements).

The passenger system development took into account (in depth) the problem of the forward positioned child. The final design, nevertheless, is flexible enough that, if there were a change in priority between the protection of the out-of-position child and the protection of the normally seated adult, the passenger restraint design could simply be optimized to the new situation. A major redesign of the system should not be necessary.

The modification of the driver system successfully protected the driver surrogate in the sixth barrier test. The injury levels in that test were amply below the maximum acceptable limits. On the other hand, the results of the seventh vehicle barrier test brought up a question of the performance repeatability of the design. In that test the failure of the steering column to stroke caused the driver's chest acceleration to exceed the injury criterion. Moreover, during sled testing the column exhibited inconsistent stroking characteristics (with its stroke averaging from 1/2 to 3-1/2 inches). These results indicate that something more than a minor redesign of the Volvo's stroking steering column is required in order to attain consistently repeatable results.

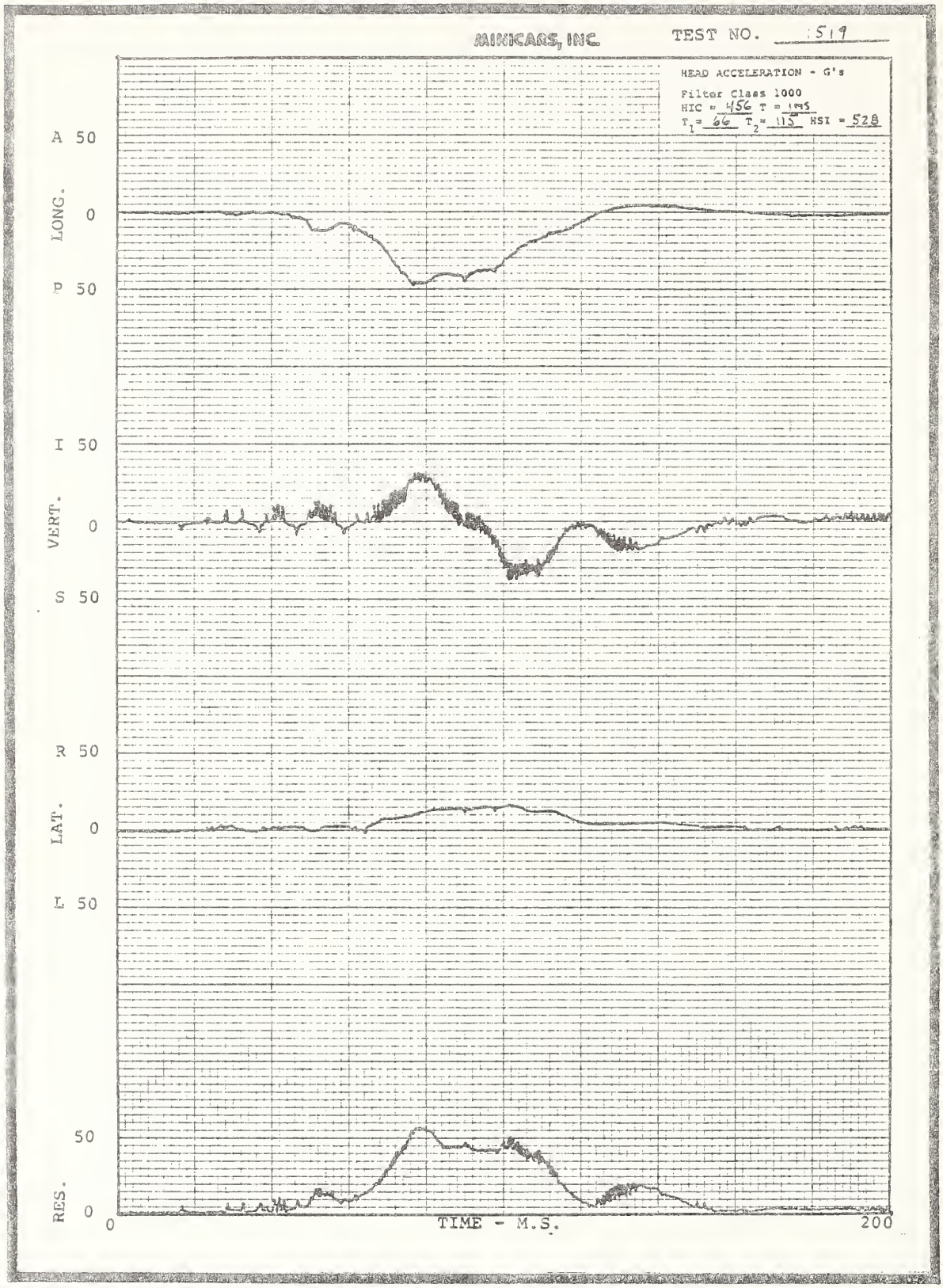
One option would be the column design developed by Minicars under NHTSA Contract DOT-HS-6-01412. This is the Minicars "tube and mandrel" column, which exhibits highly stable stroking characteristics (even under the extreme upload conditions placed upon it by the driver's interaction with the airbag and steering wheel). This column has been successfully employed in a wide variety of developmental

airbag systems – including ones built for the Vega, Chevette, Omni, Minicars RSV, and the Citation (recently completed under Contract DOT-HS-8-01809).

Further redesign of the steering column should improve the consistency of the performance of the driver system to the excellent levels achieved in Barrier Crash 6.

The minor modifications required to increase the performance level of the stock Volvo seat belt system were also successfully determined in this program. Merely by shortening the overall belt length, and thus reducing the "spool-out", we were able to protect 50th percentile males in 35 mph BEV crashes. It was also found that this belt shortening should not unduly compromise the comfort of the full size range of occupants when they are situated in reasonable seating positions.

APPENDIX A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I 50
VERT.
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R 50
LAT.
0
L 50
50
RES.
0
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TIME - M.S.
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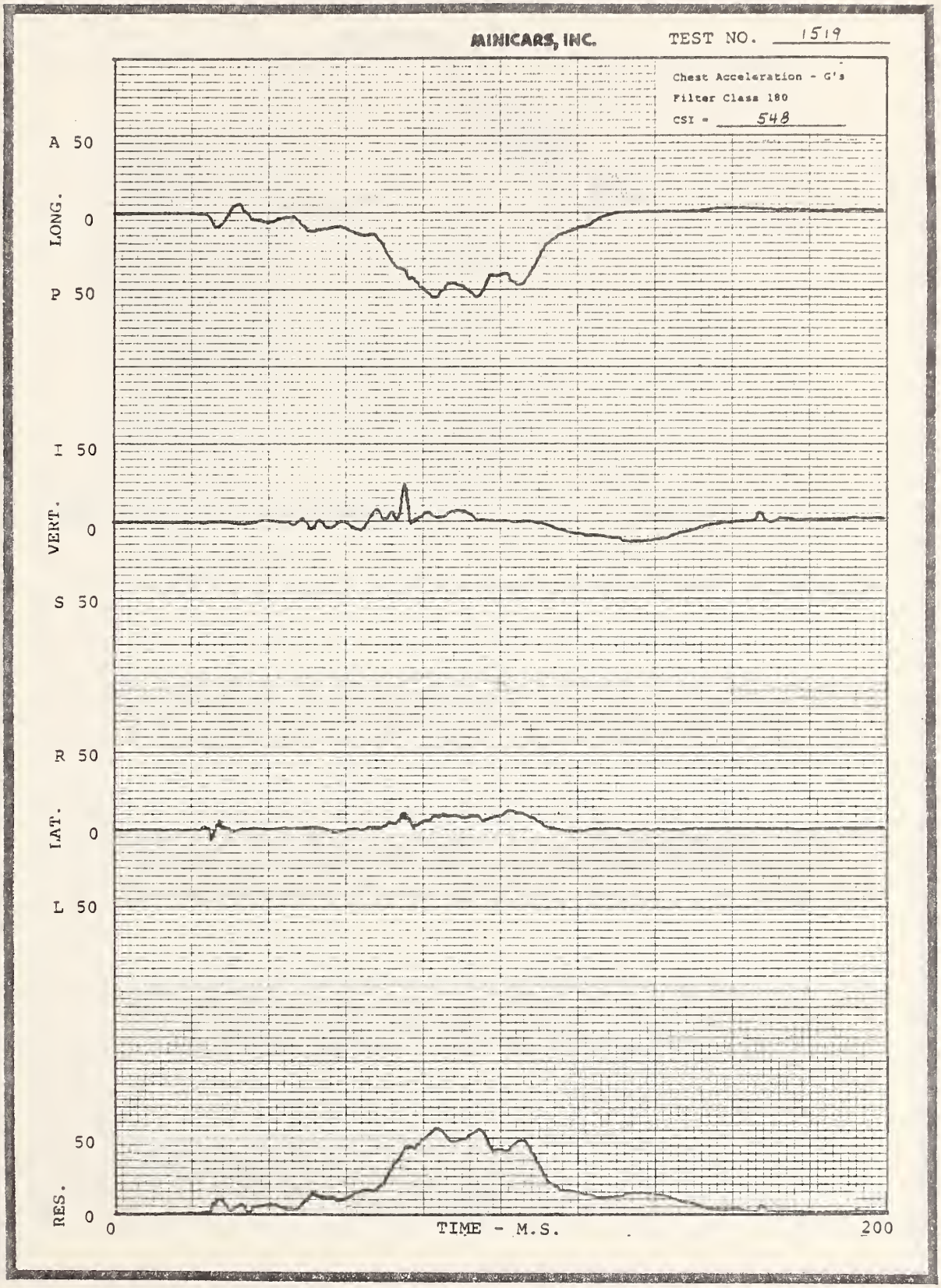
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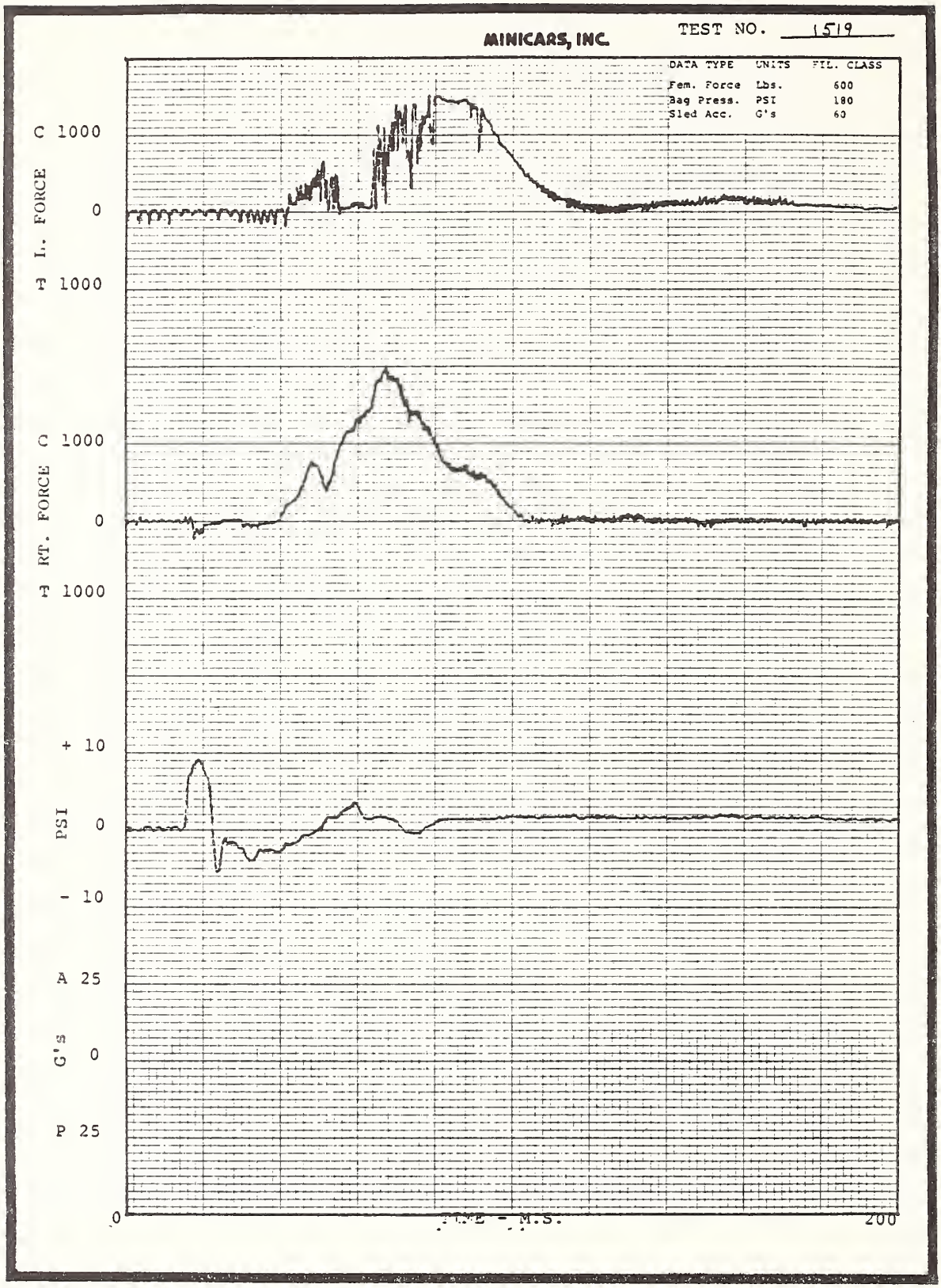
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Sled Acc. G's 60
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C 1000
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+ 10
PSI 0
- 10
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G's 0
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TIME - M.S.
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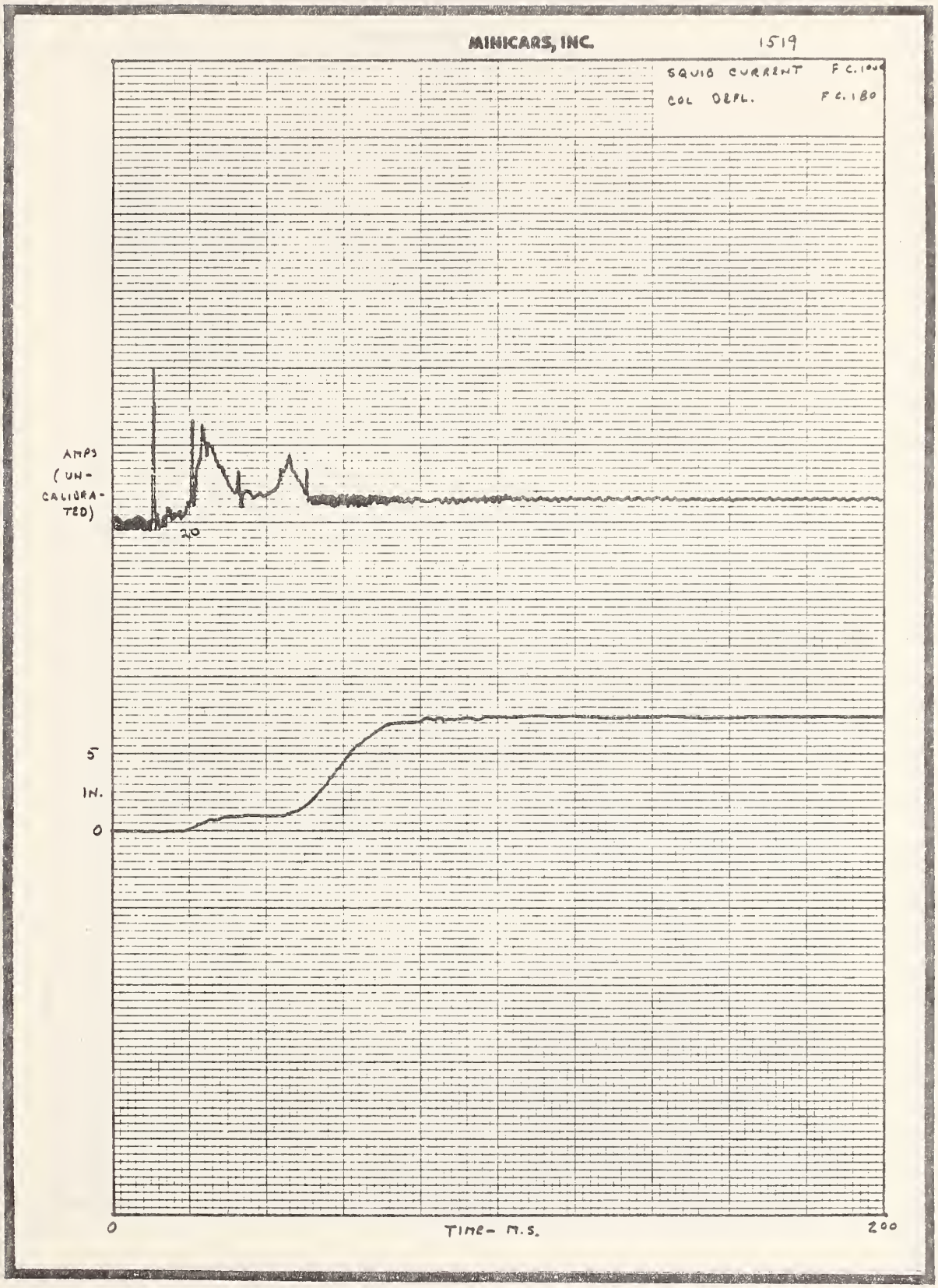
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1519
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COL DEFL.
AMPS (UN-CALIBRATED)
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IN.
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TIME- M.S.
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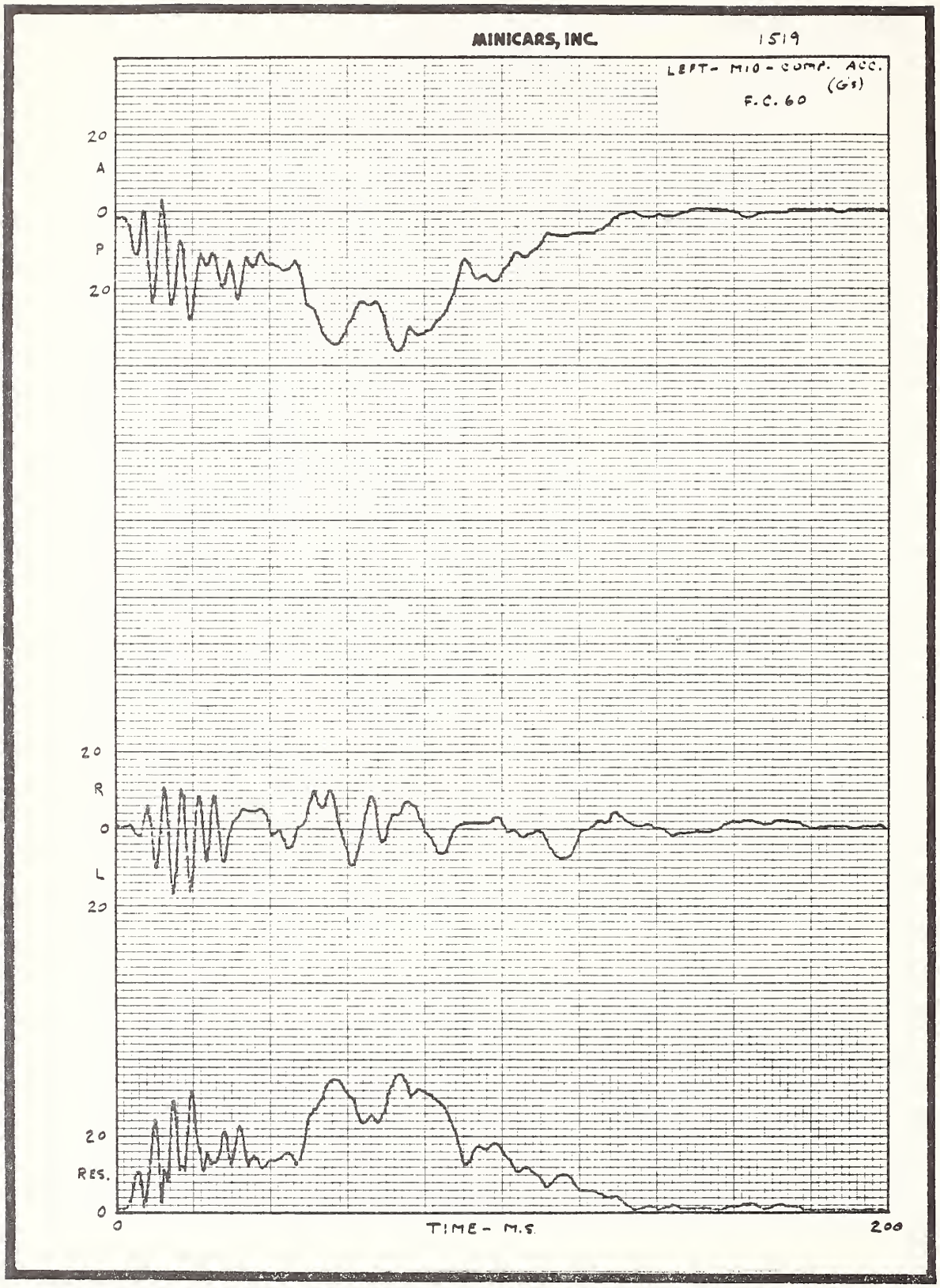
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TIME - M.S.
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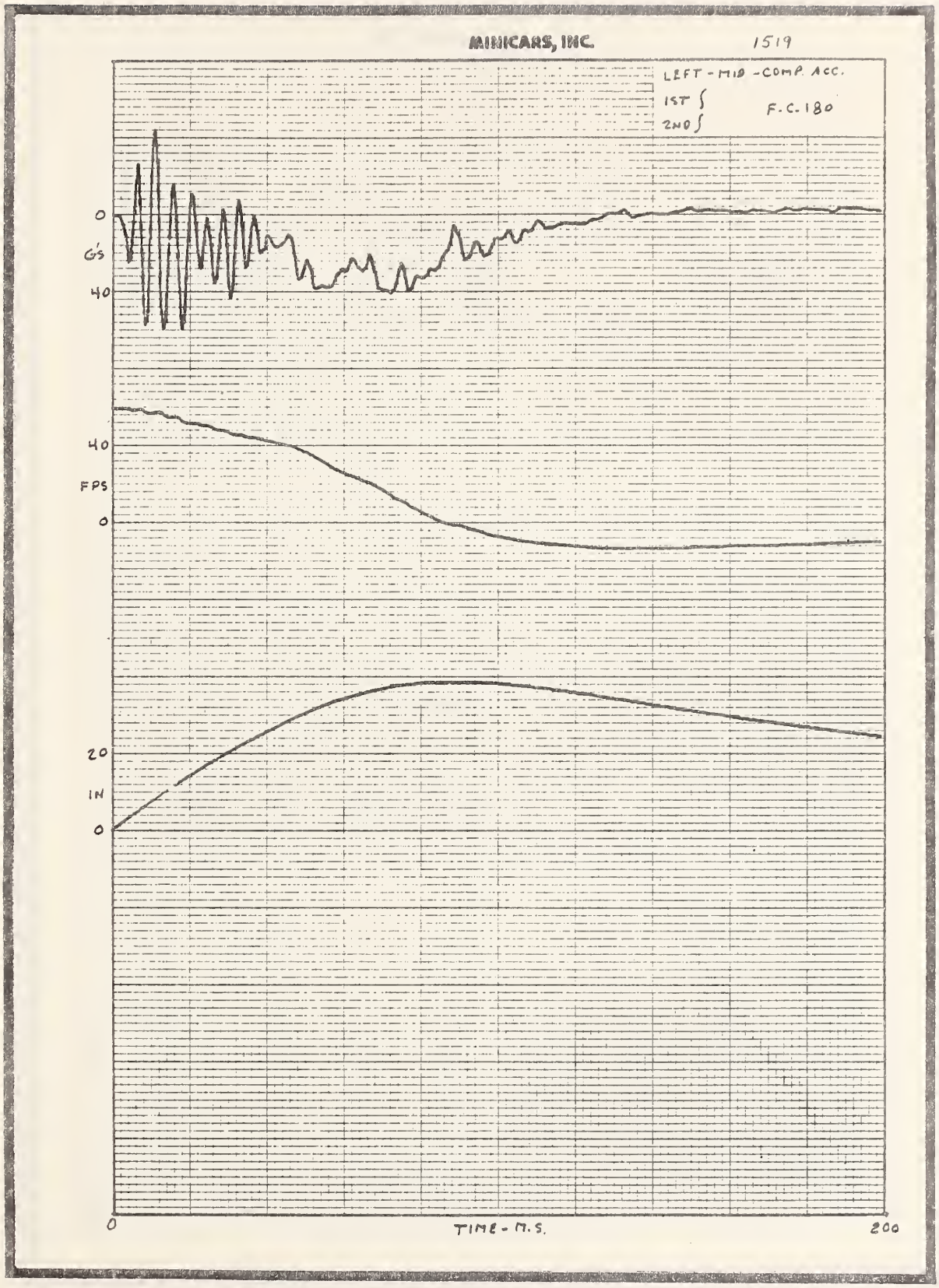
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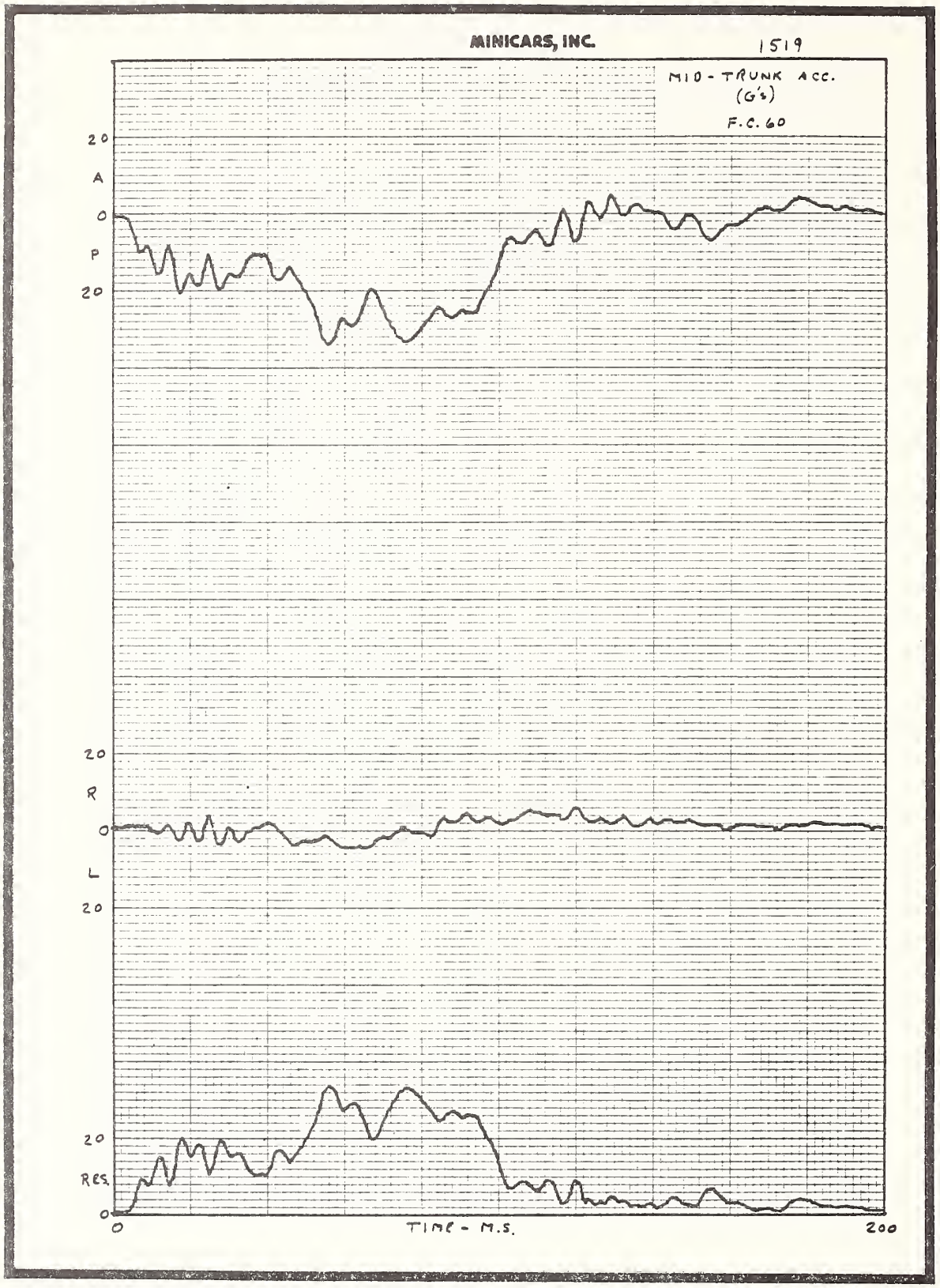
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(G's)
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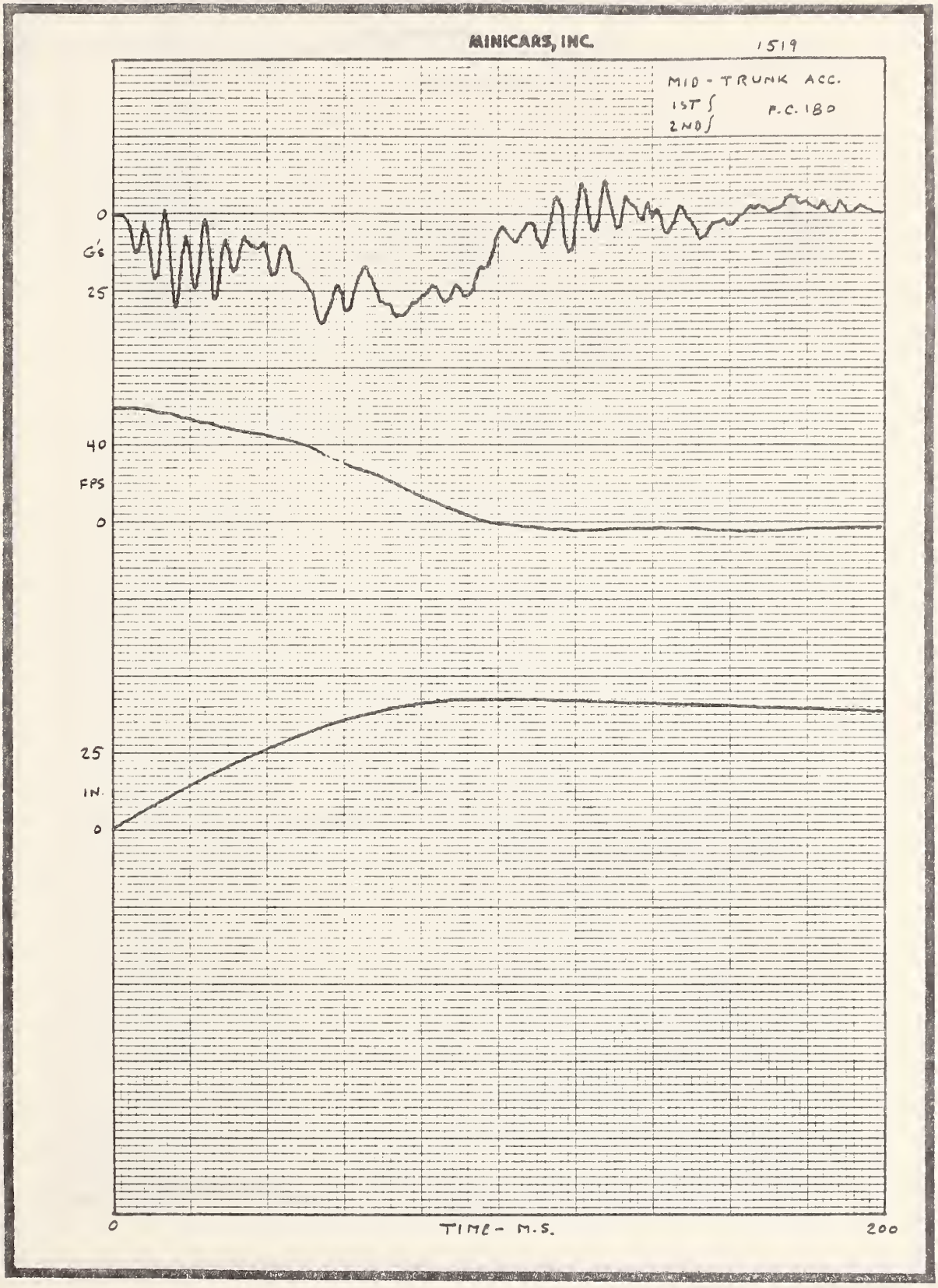
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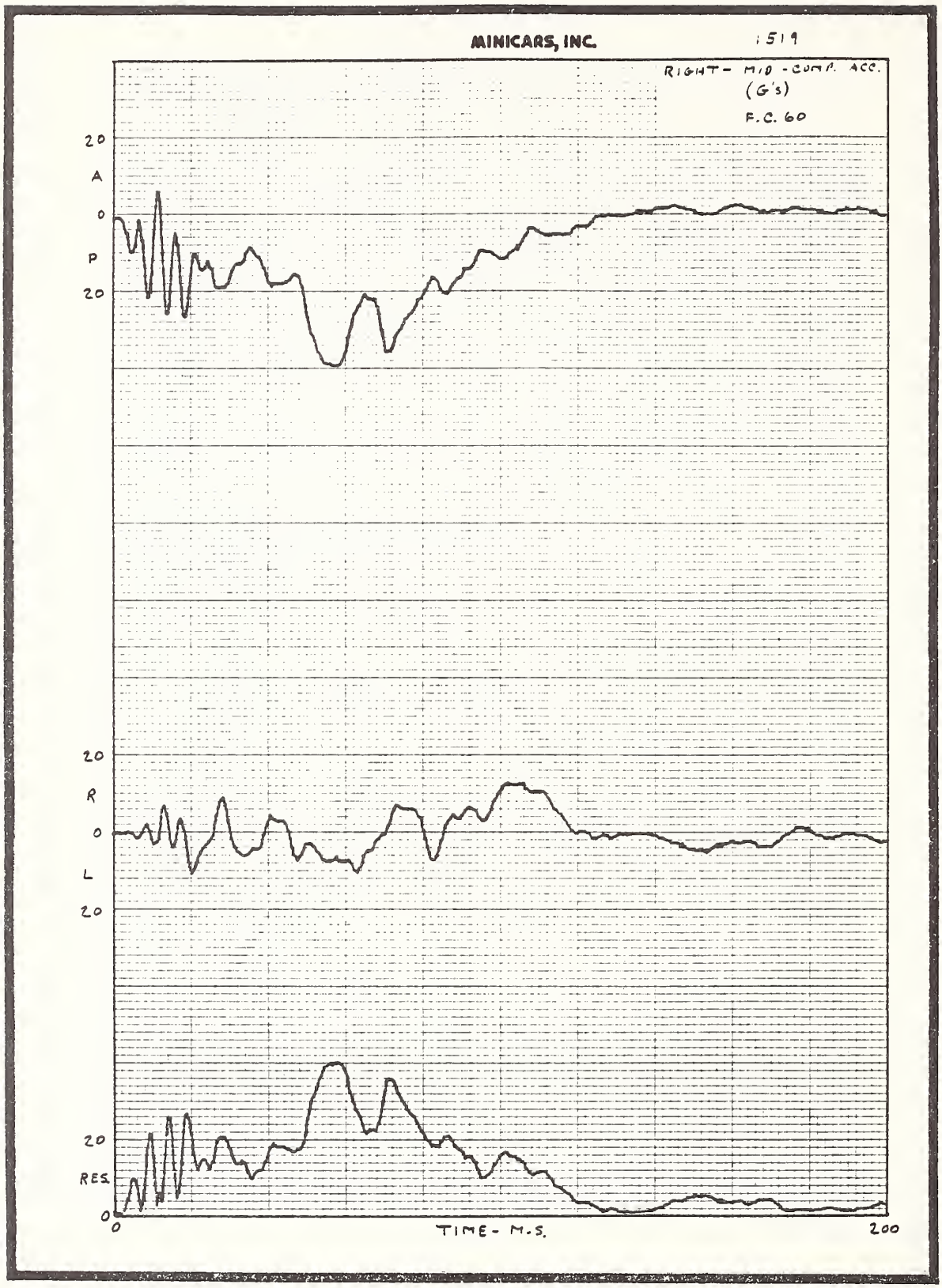
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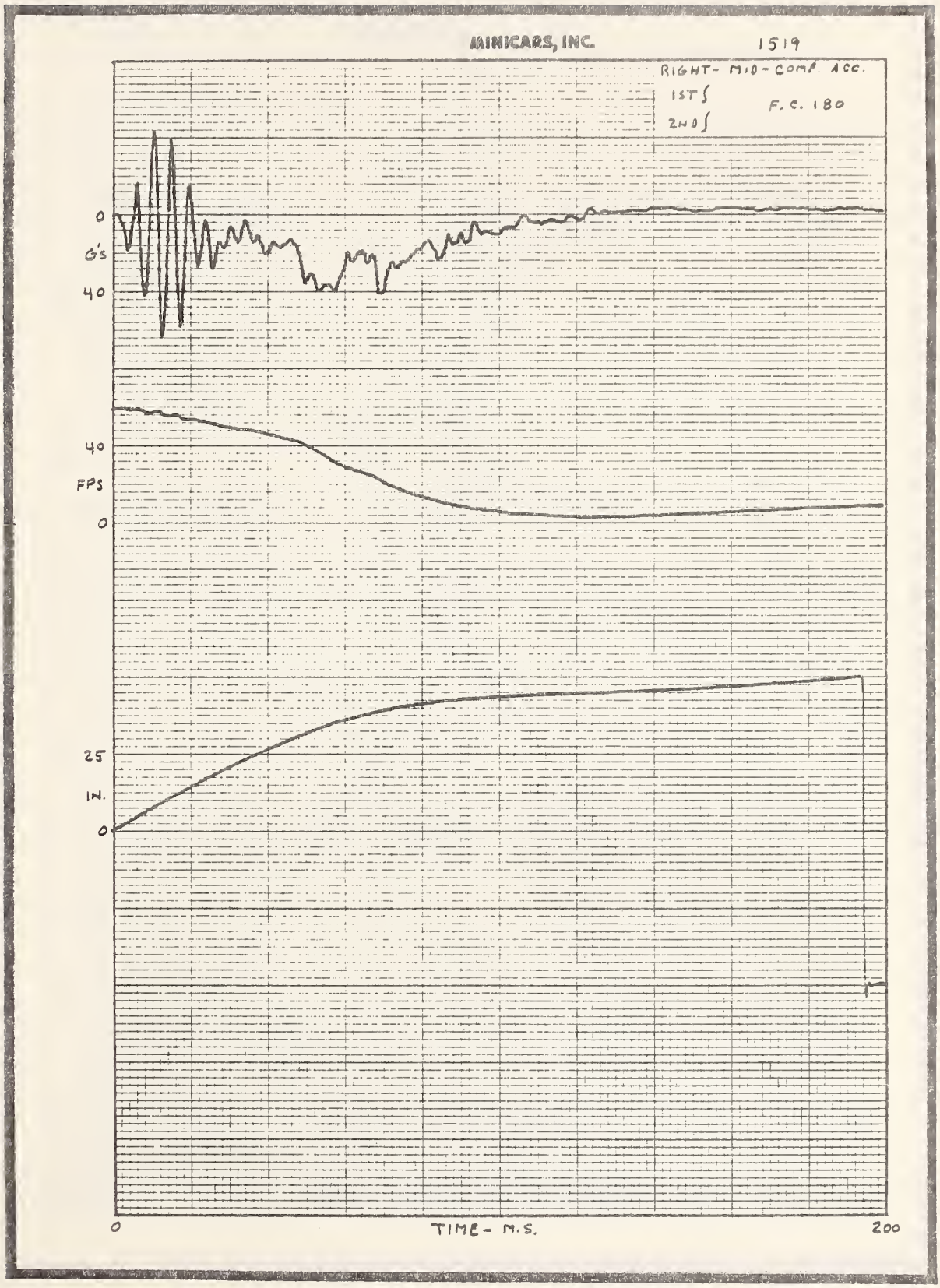
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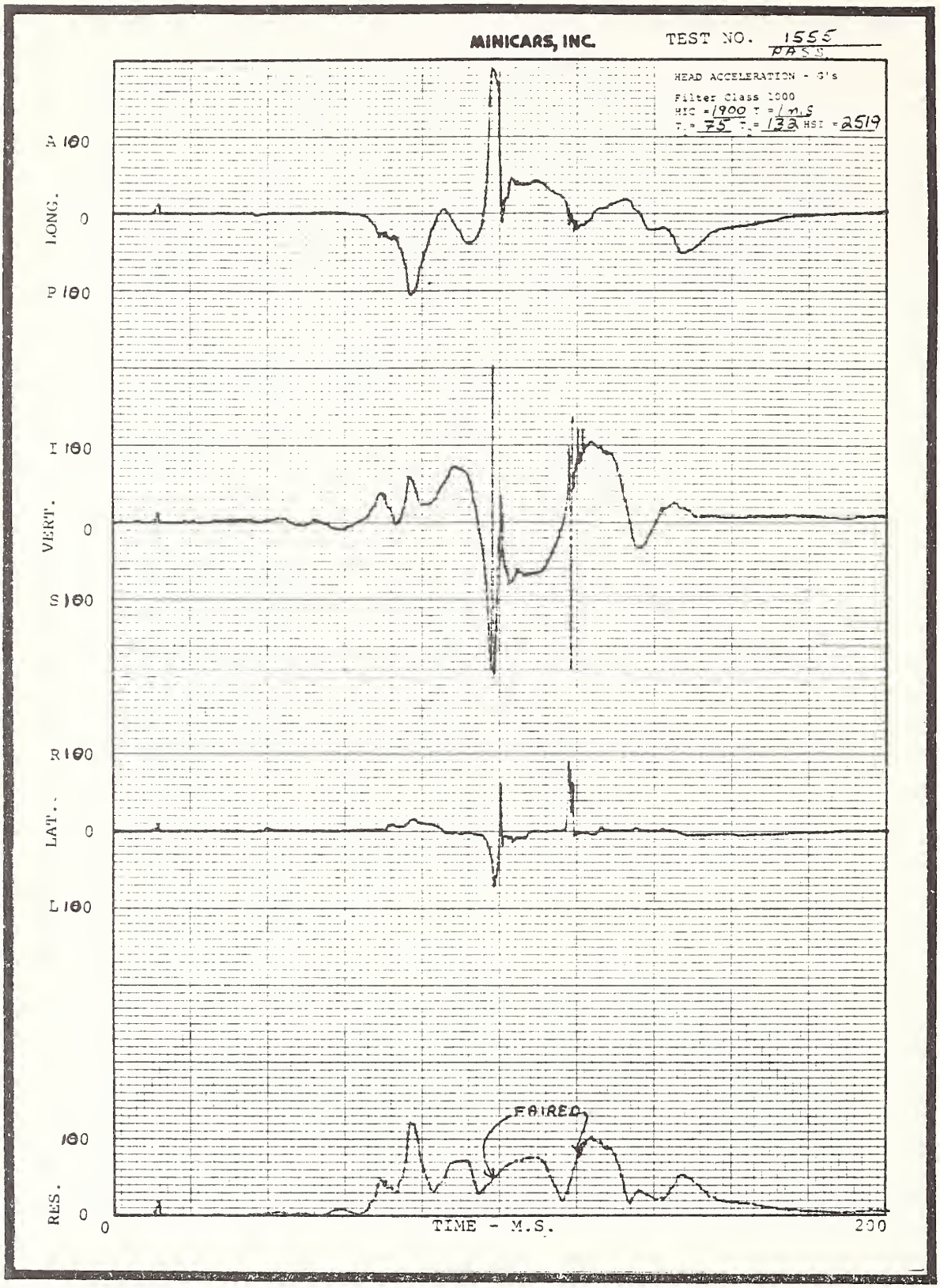
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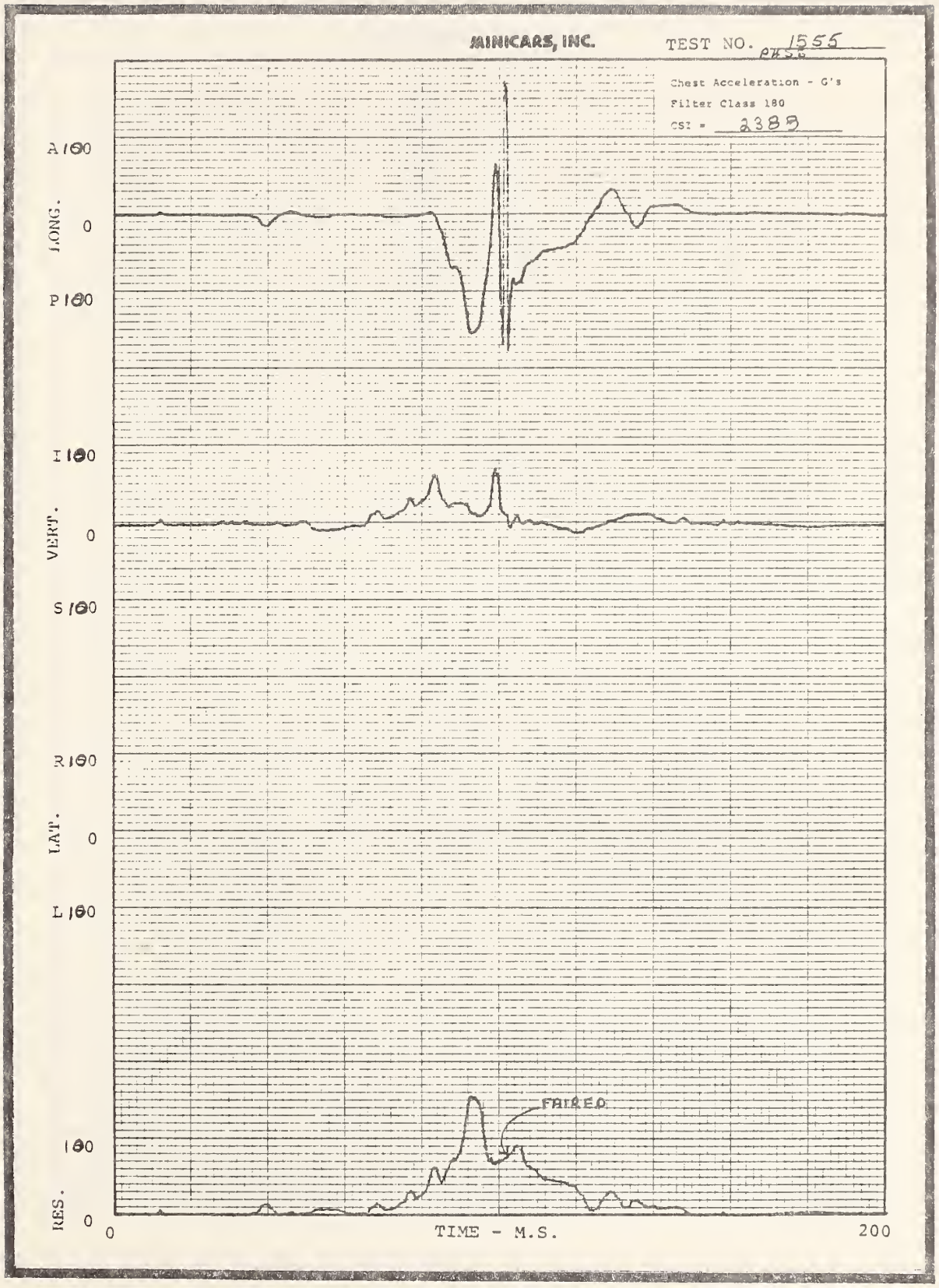
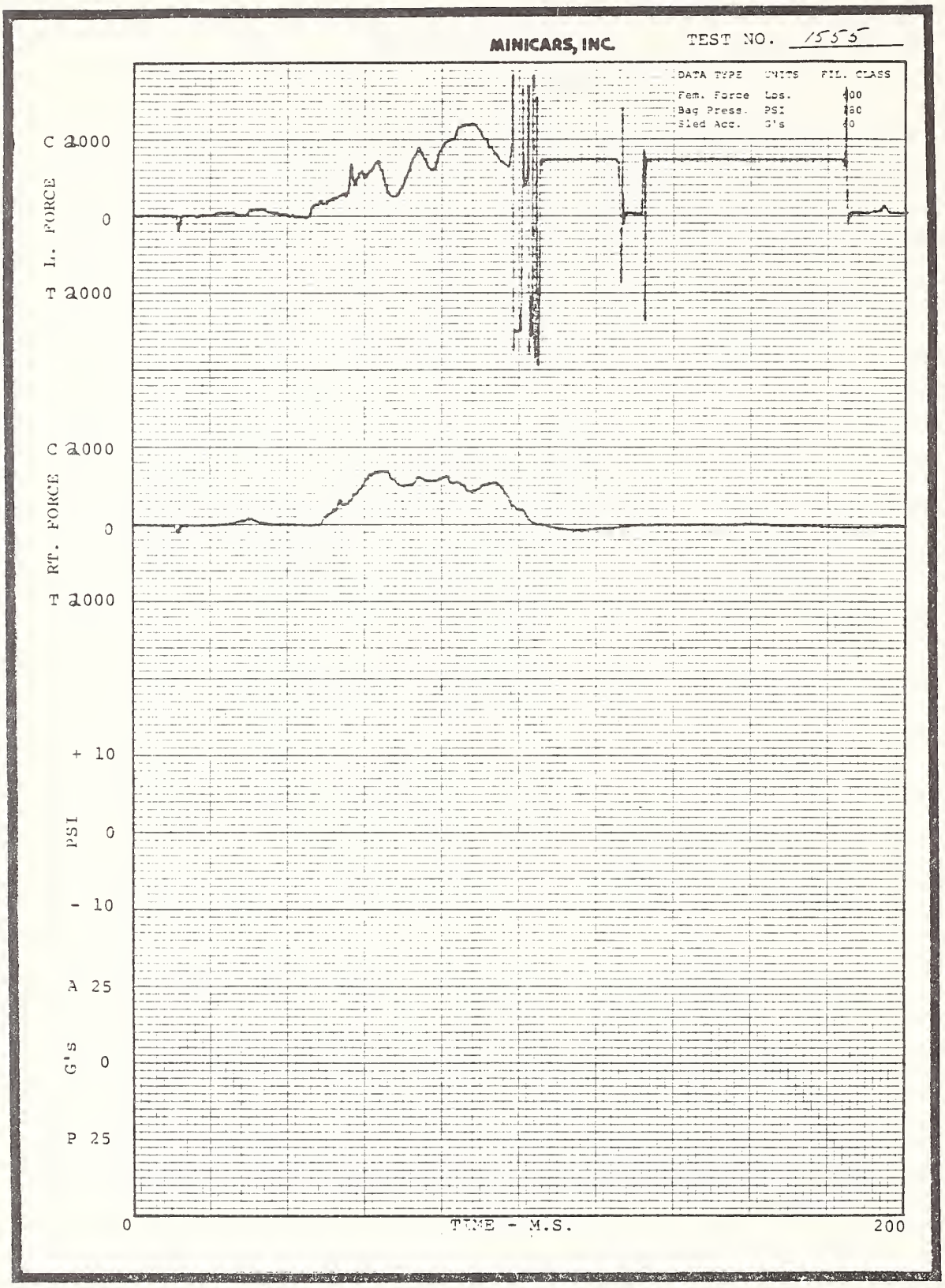
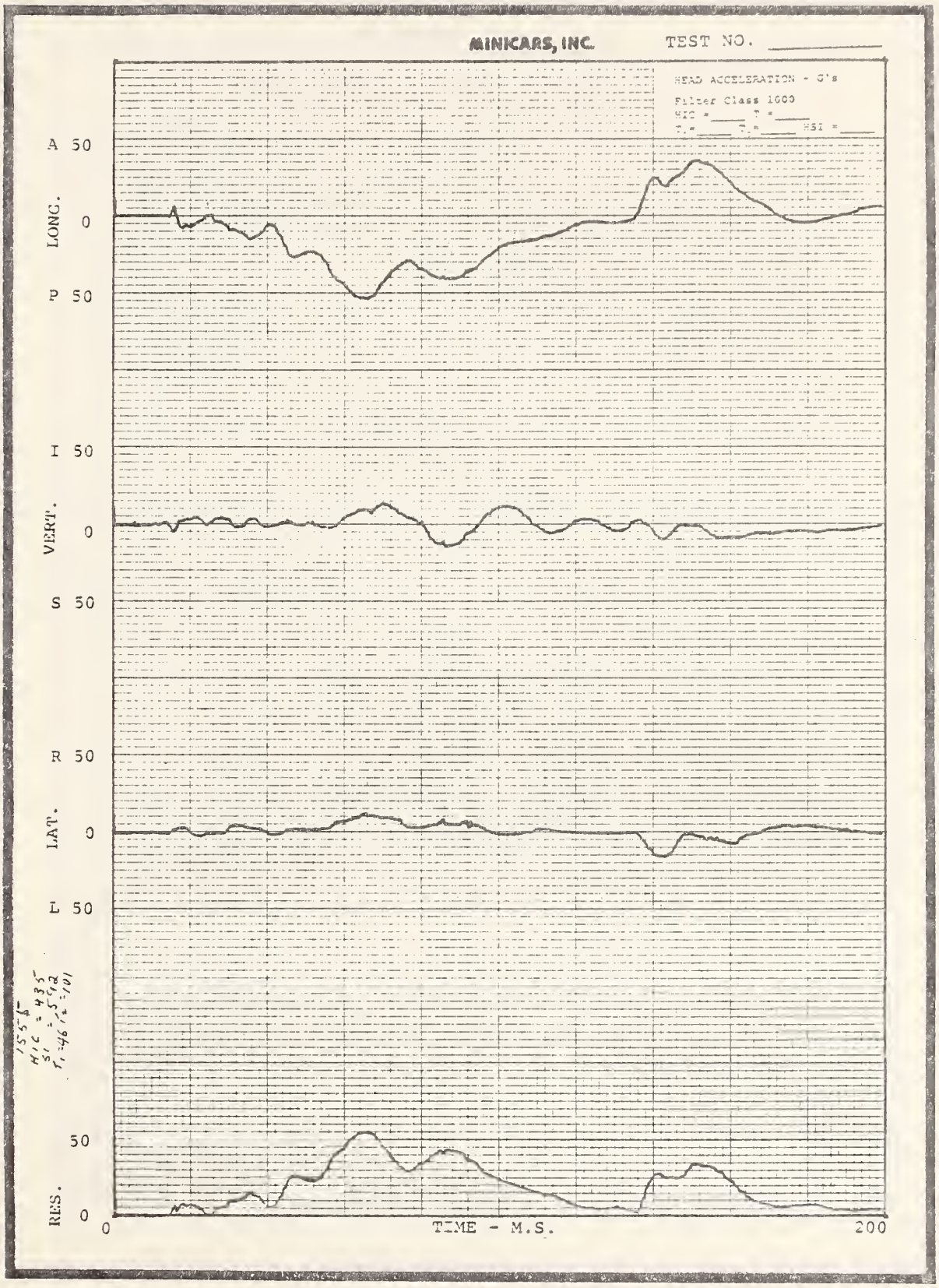
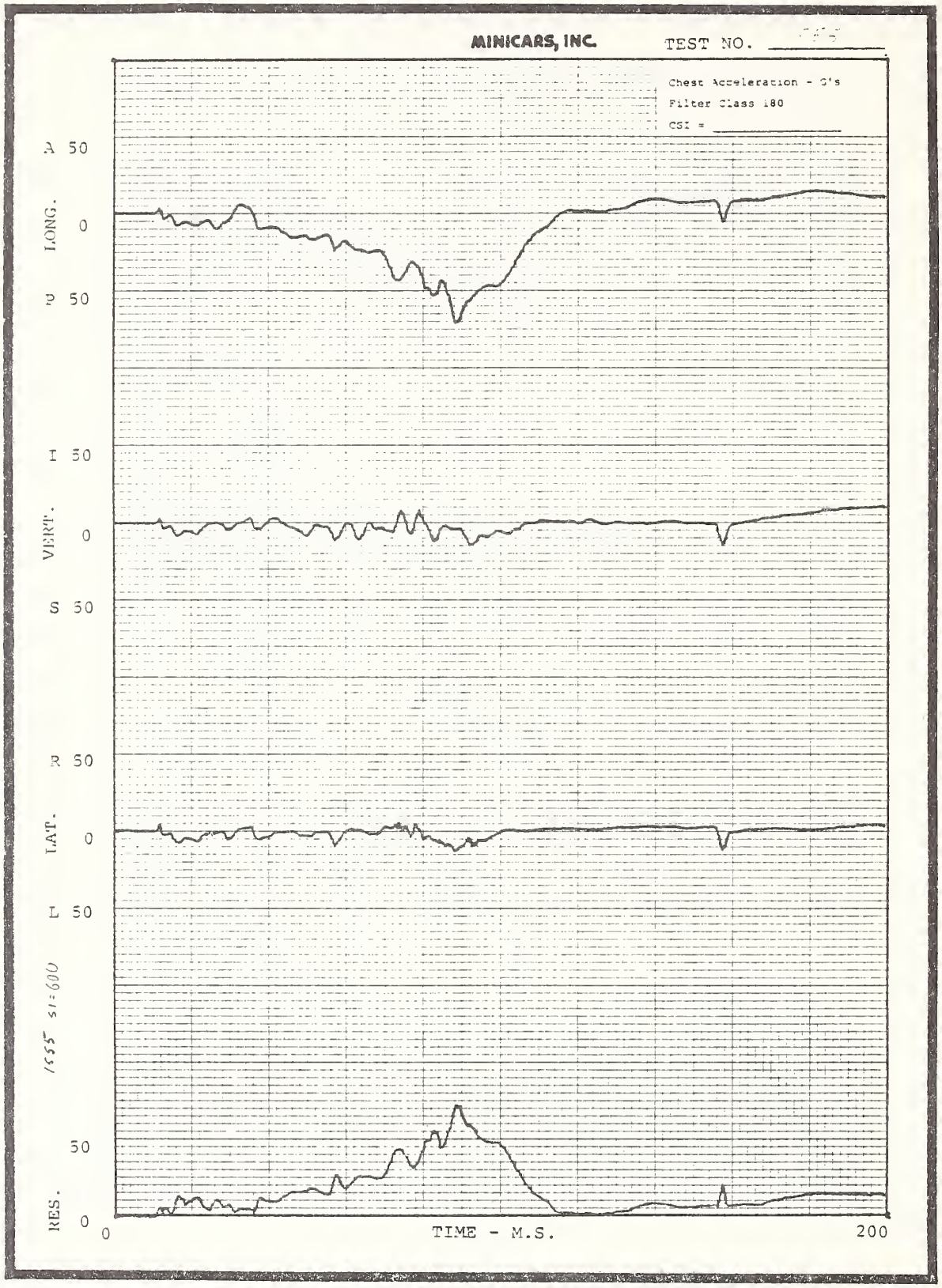
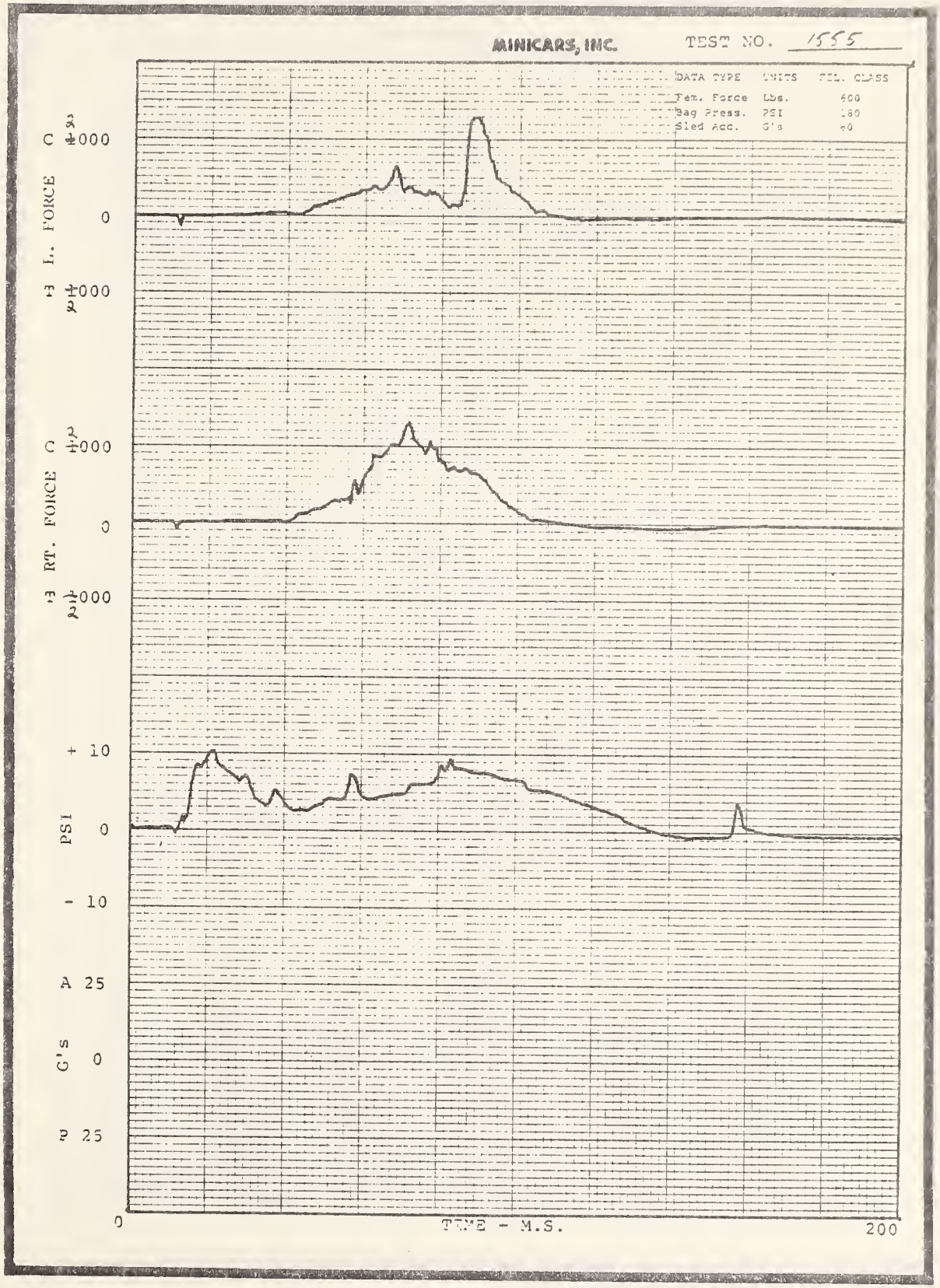
Filter Class 1000
HIC = 1900 T = 1 m.s
T = 75 T = 132 HSI = 2519
A 100
LONG.
0
P 100
I 100
VERT.
0
S 100
R 100
LAT.
0
L 100
FAIRED
100
RES.
0
0
TIME - M.S.
200

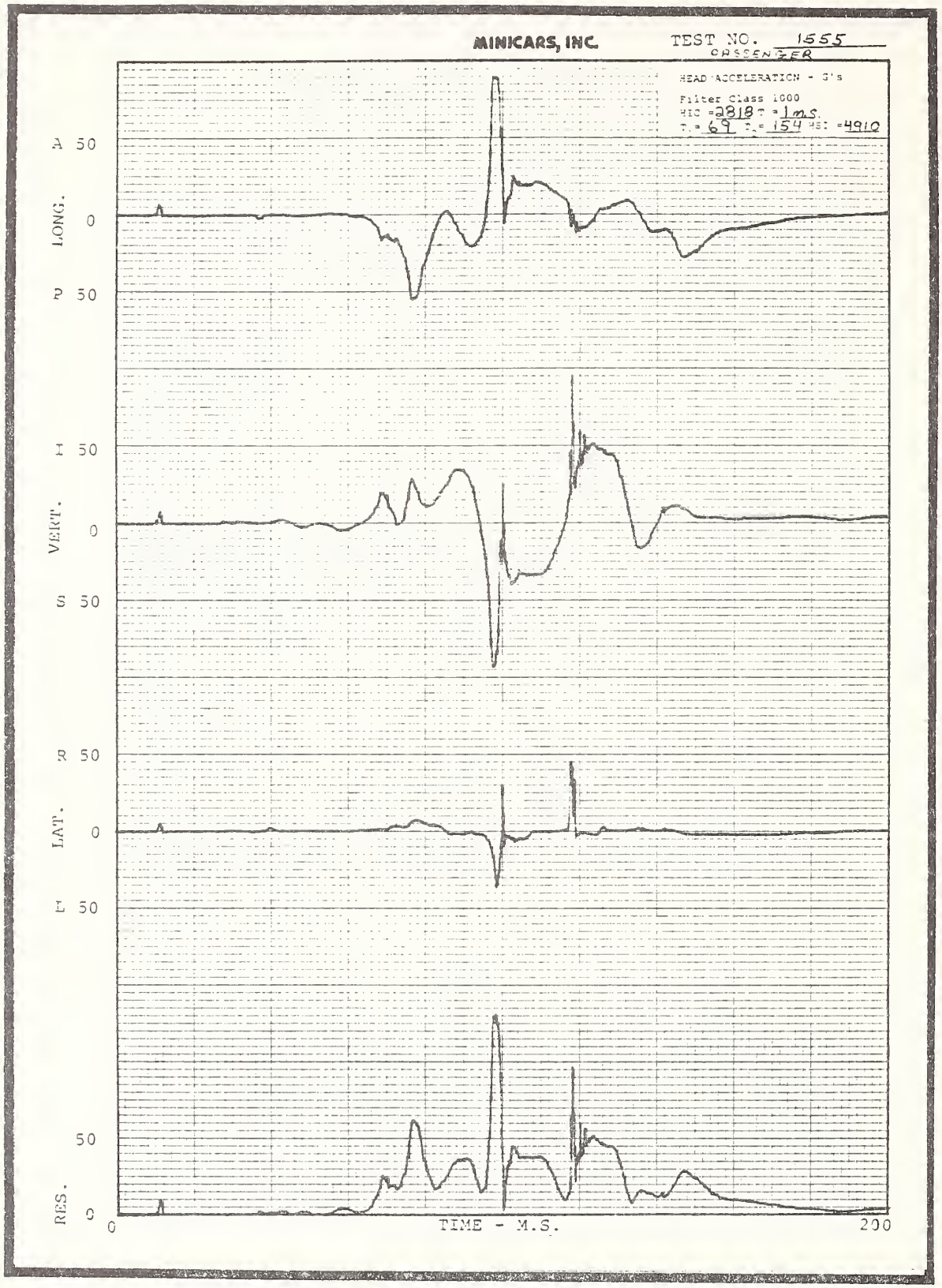

MINICARS, INC.
TEST NO. 1555
Chest Acceleration - G's
Filter Class 180
CSI = 2388
A 100
LONG.
0
P 100
I 100
VERT.
0
S 100
R 100
LAT.
0
L 100
FAIRED
100
RES.
0
0
TIME - M.S.
200

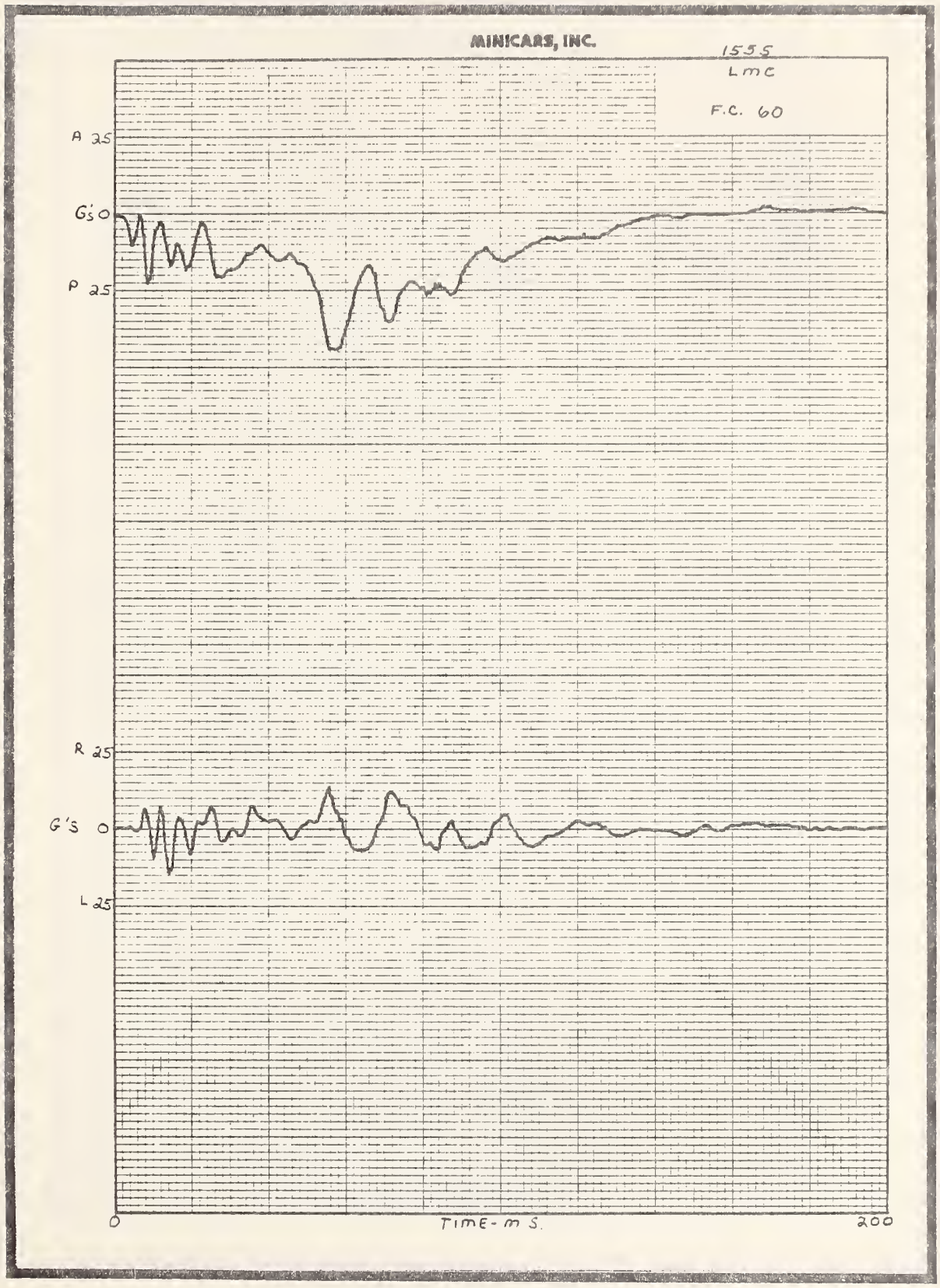

MINICARS, INC.
TEST NO. 15555
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 400
Bag Press. PSI 180
Sled Acc. G's 40
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

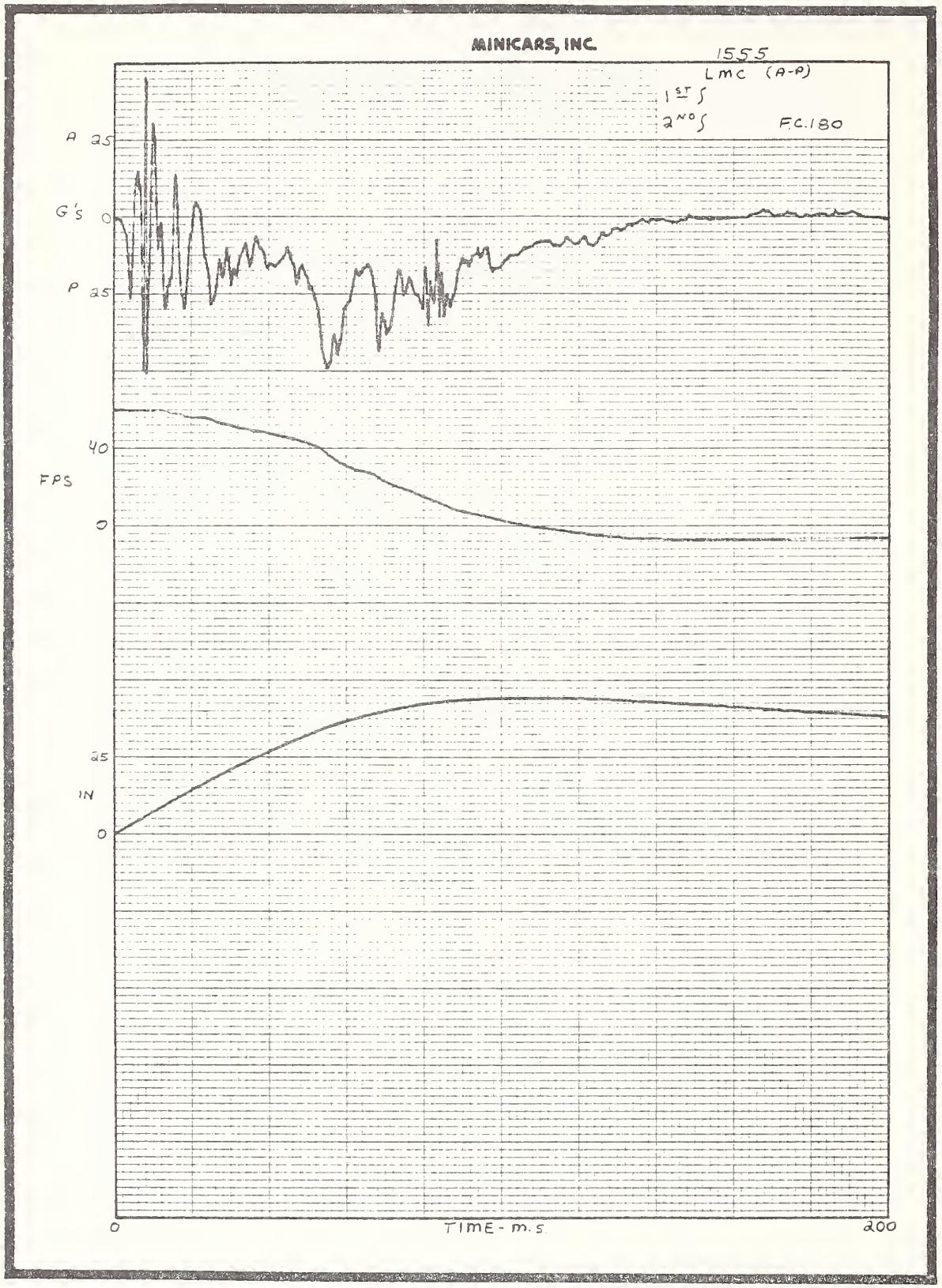

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

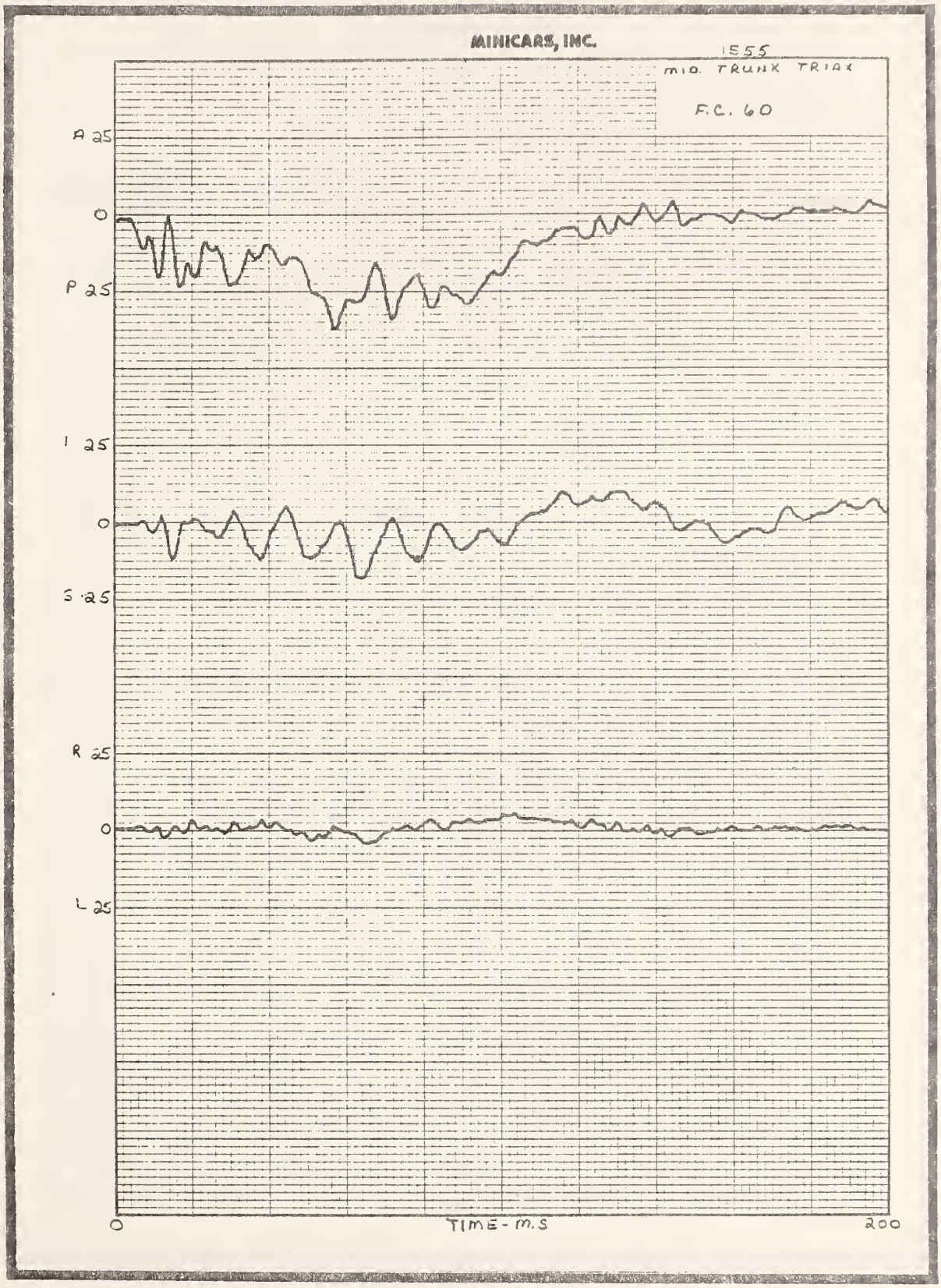

MINICARS, INC.
TEST NO.
Chest Acceleration - G's
Filter Class 180
CSI =
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

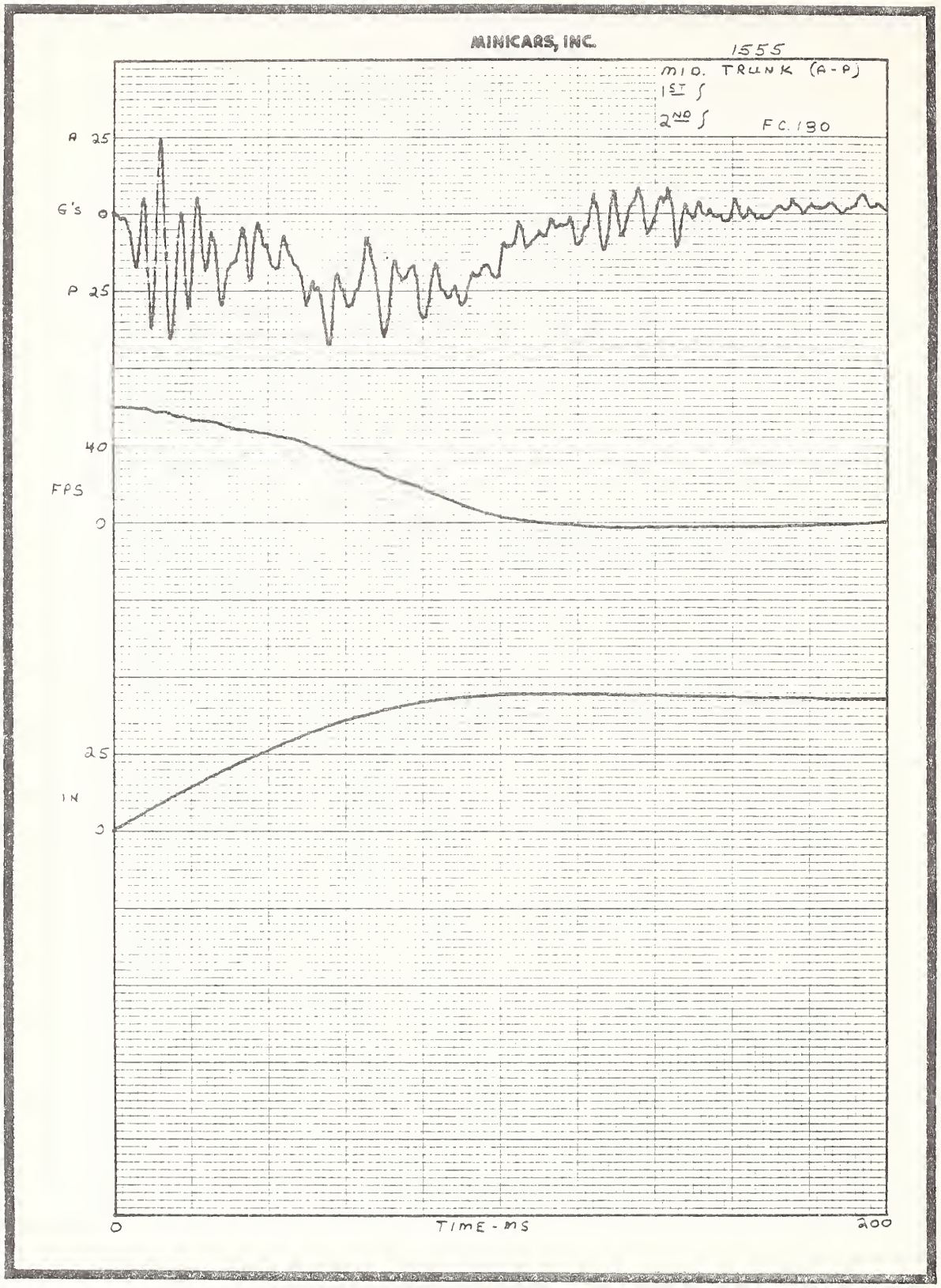

MINICARS, INC.
TEST NO. 1555
DATA TYPE UNITS CEL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 160
Sled Acc. G's 60
LT. FORCE LBS
+4000
0
-4000
RT. FORCE LBS
+4000
0
-4000
PSI
+ 10
0
- 10
G's
A 25
0
P 25
0
TIME - M.S.
200

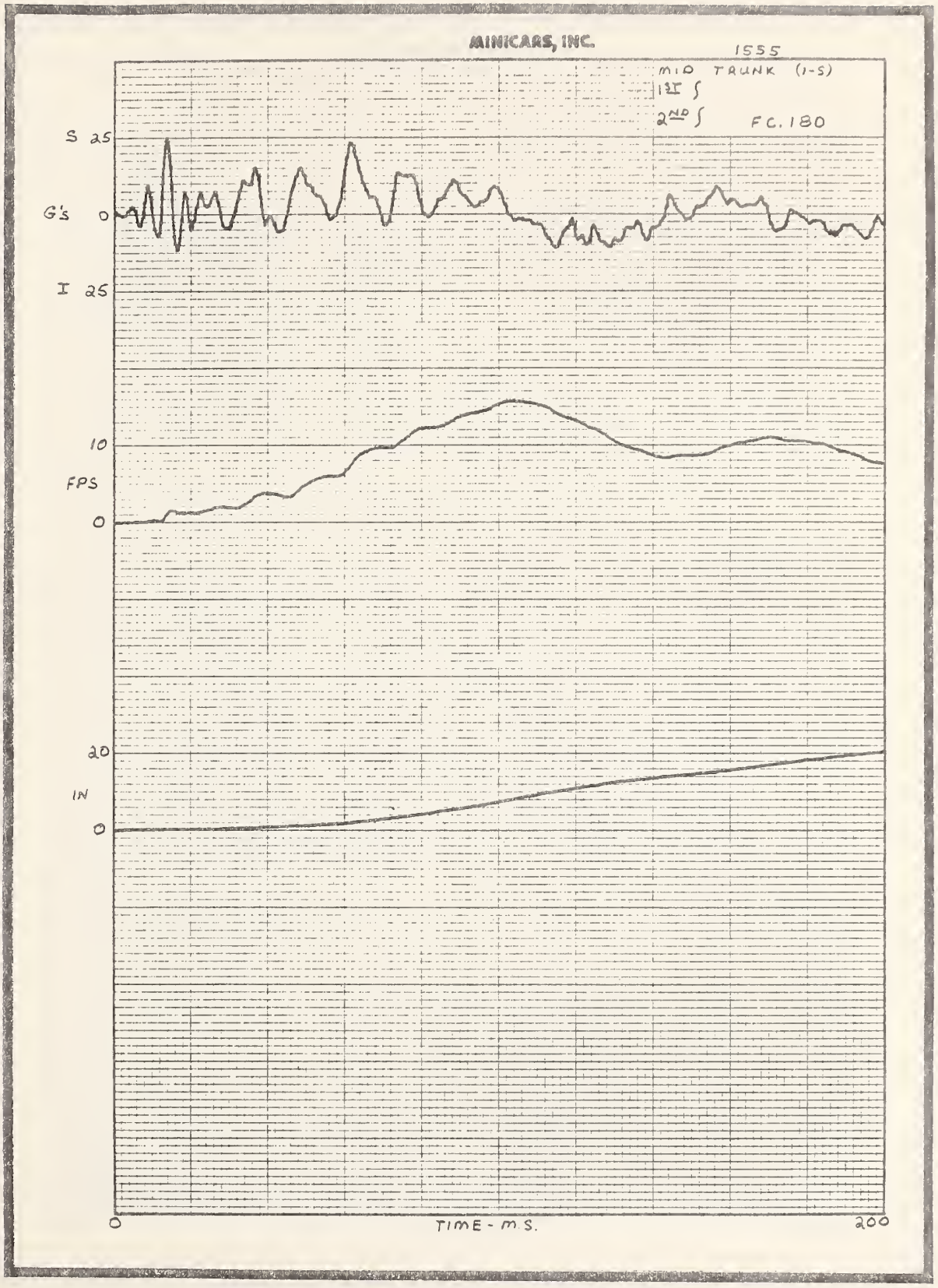

MINICARS, INC.
TEST NO. 1555
PASSENGER
HEAD ACCELERATION - G's
Filter Class 1000
HIC =2818 T =1ms
T= 69 T= 154 HSI =4910
A 50
LONG.
0
P 50
H 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

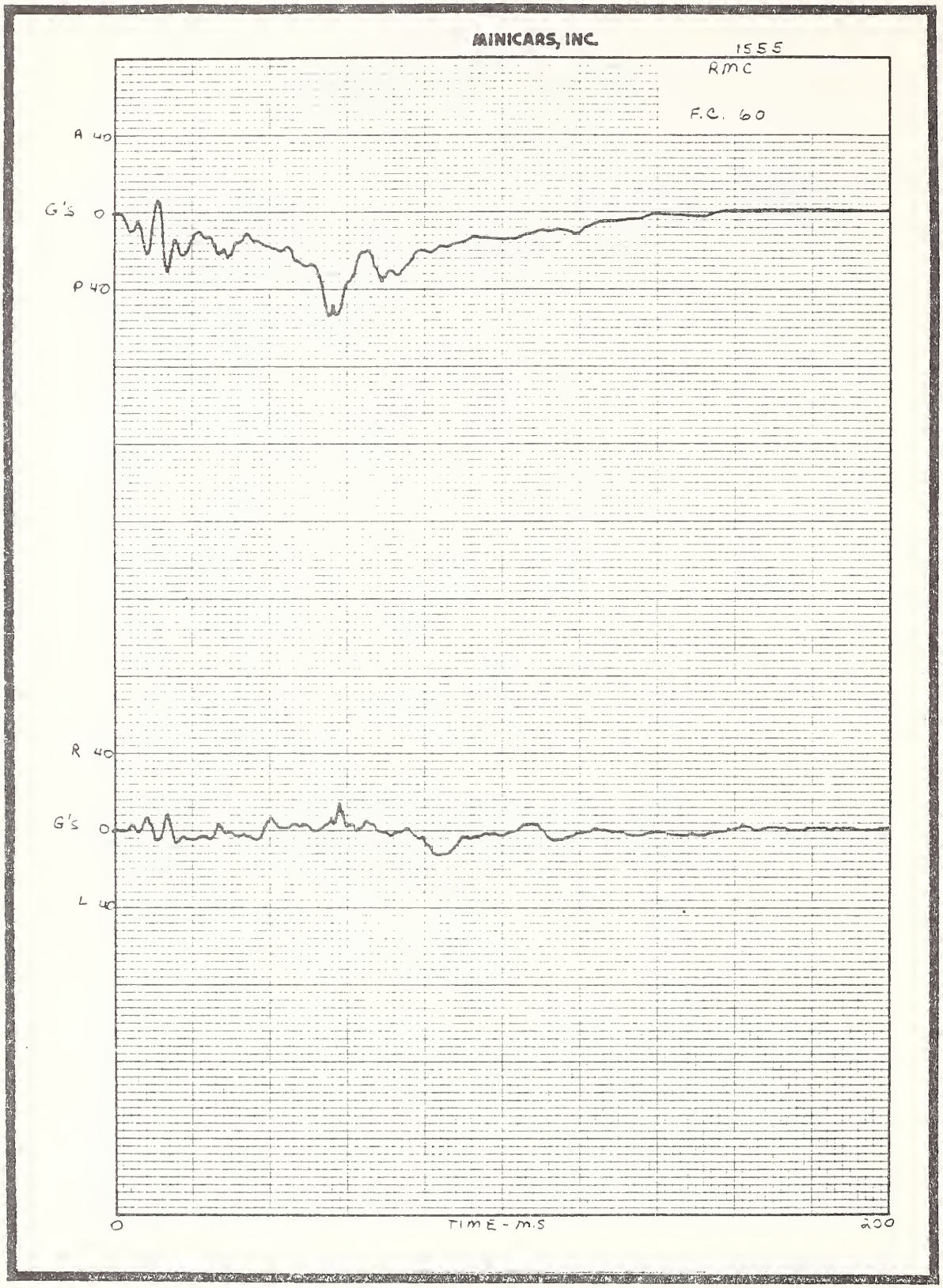

MINICARS, INC.
1555
LMC
F.C. 60
A 25
G's 0
P 25
R 25
G's 0
L 25
0
TIME - m S.
200

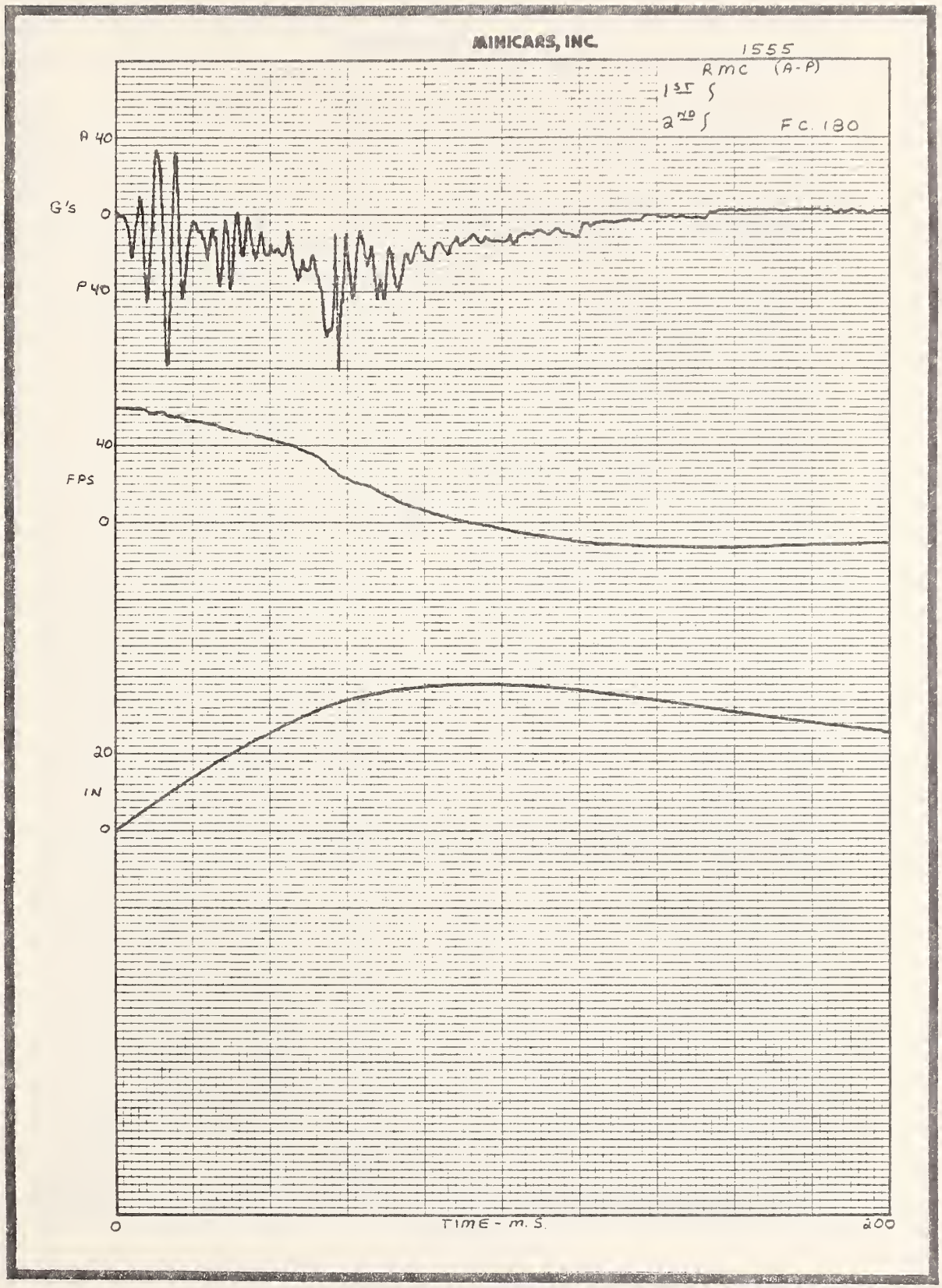

MINICARS, INC.
1555
LMC (A-P)
1ST S
2ND S
F.C.180
A 25
G'S 0
P 25
40
FPS
0
25
IN
0
0
TIME - m.s.
200

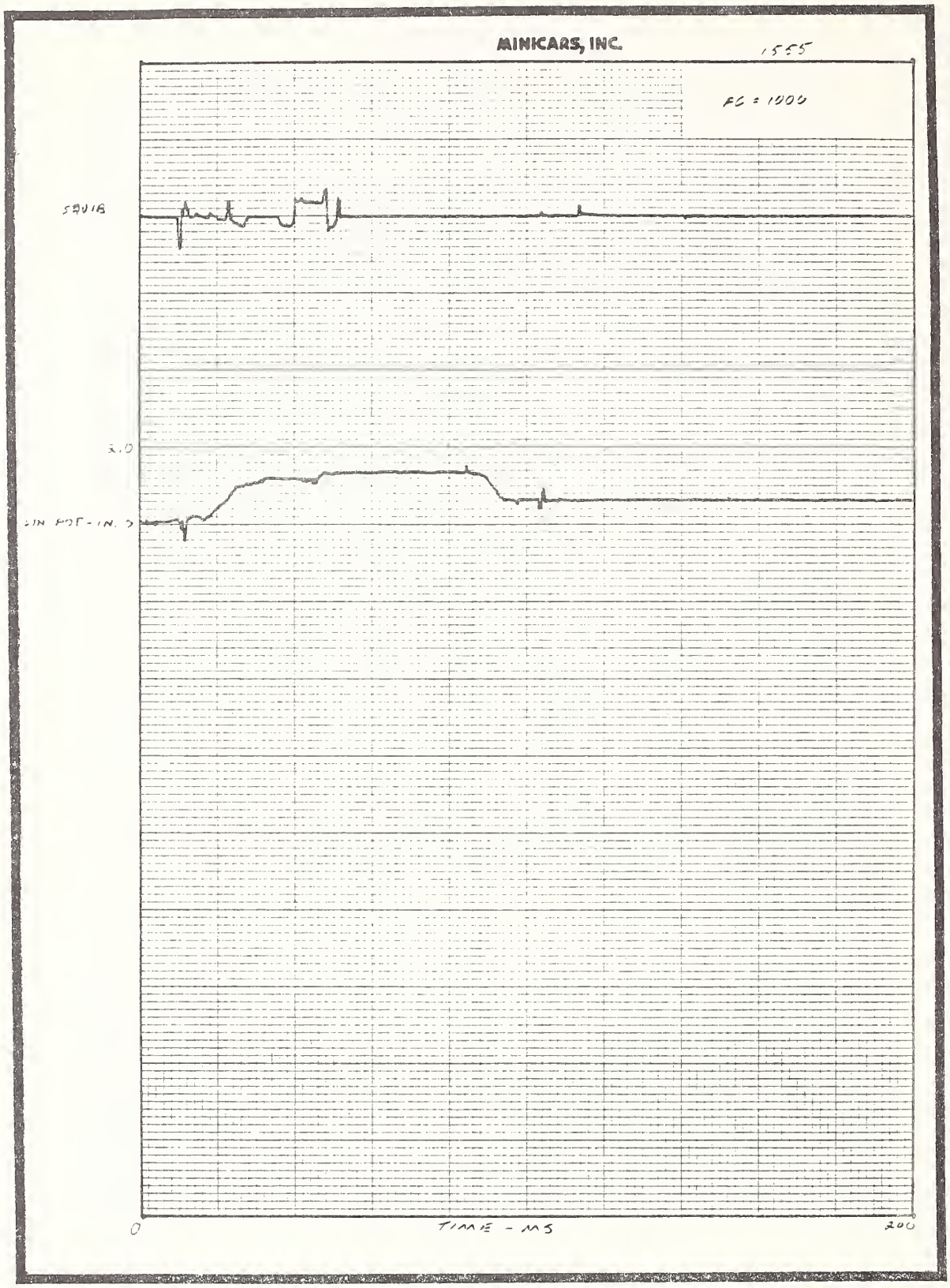

MINICARS, INC.
1555
MID. TRUNK TRIAX
F.C. 60
A 25
0
P 25
I 25
0
S 25
R 25
0
L 25
0
TIME - m.s
200

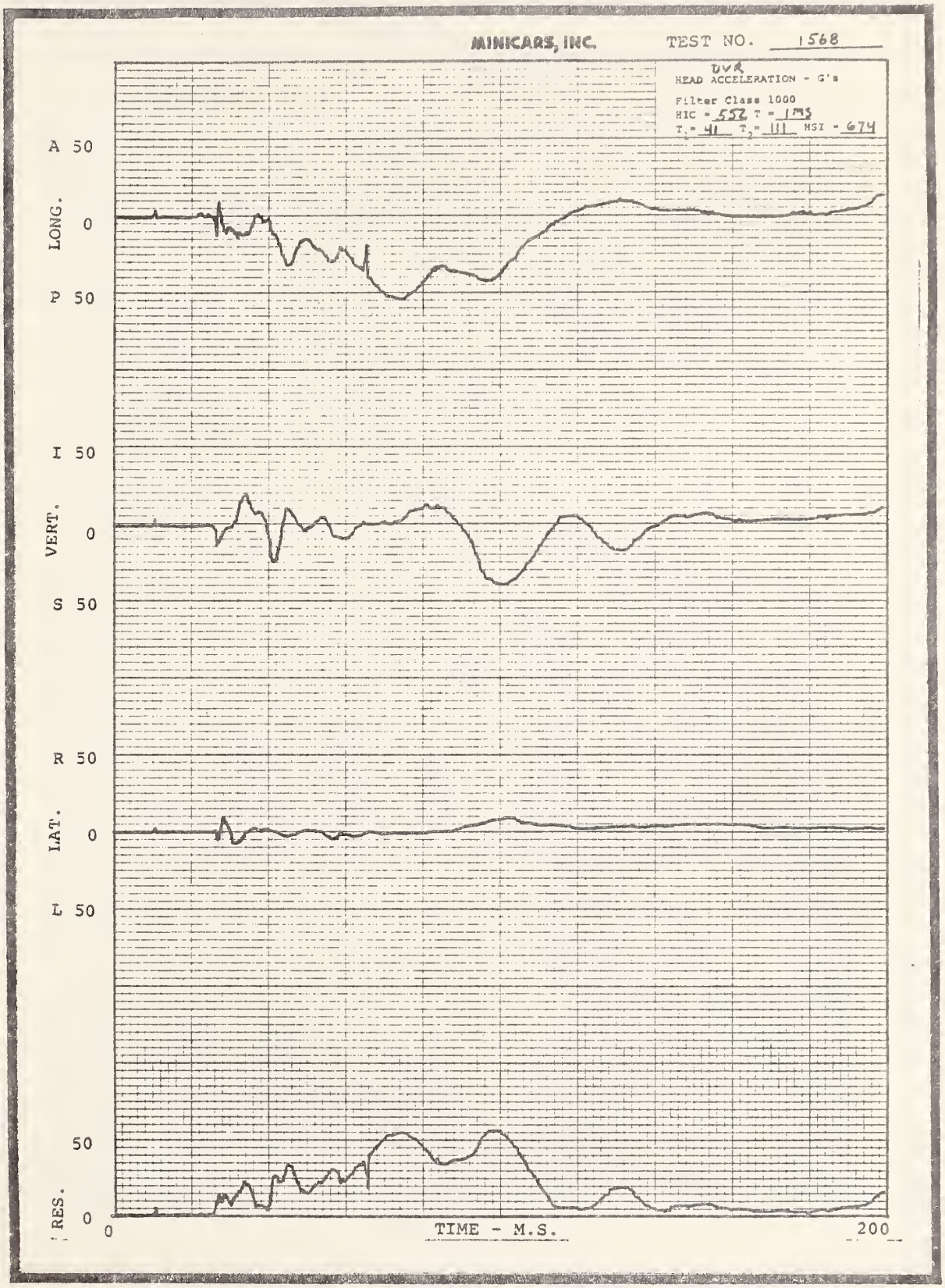

MINICARS, INC.
1555
MID. TRUNK (A-P)
1ST ∫
2ND ∫
FC.130
A 25
G's 0
P 25
40
FPS
0
25
IN
0
0
TIME - MS
200

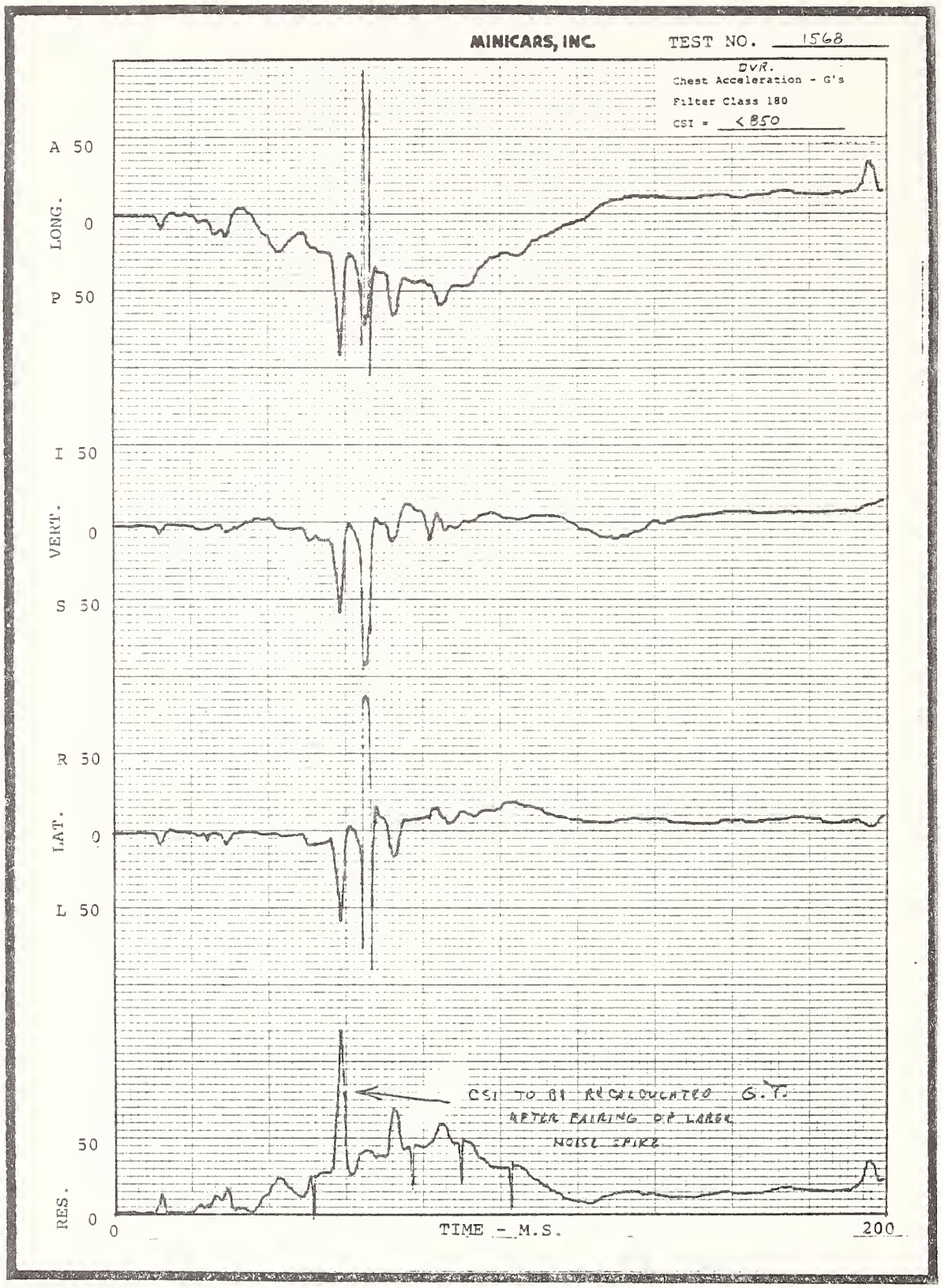

MINICARS, INC.
1555
MID TRUNK (1-S)
1ST ∫
2ND ∫
FC. 180
S 25
G's 0
I 25
10
FPS
0
20
IN
0
0
TIME - M.S.
200

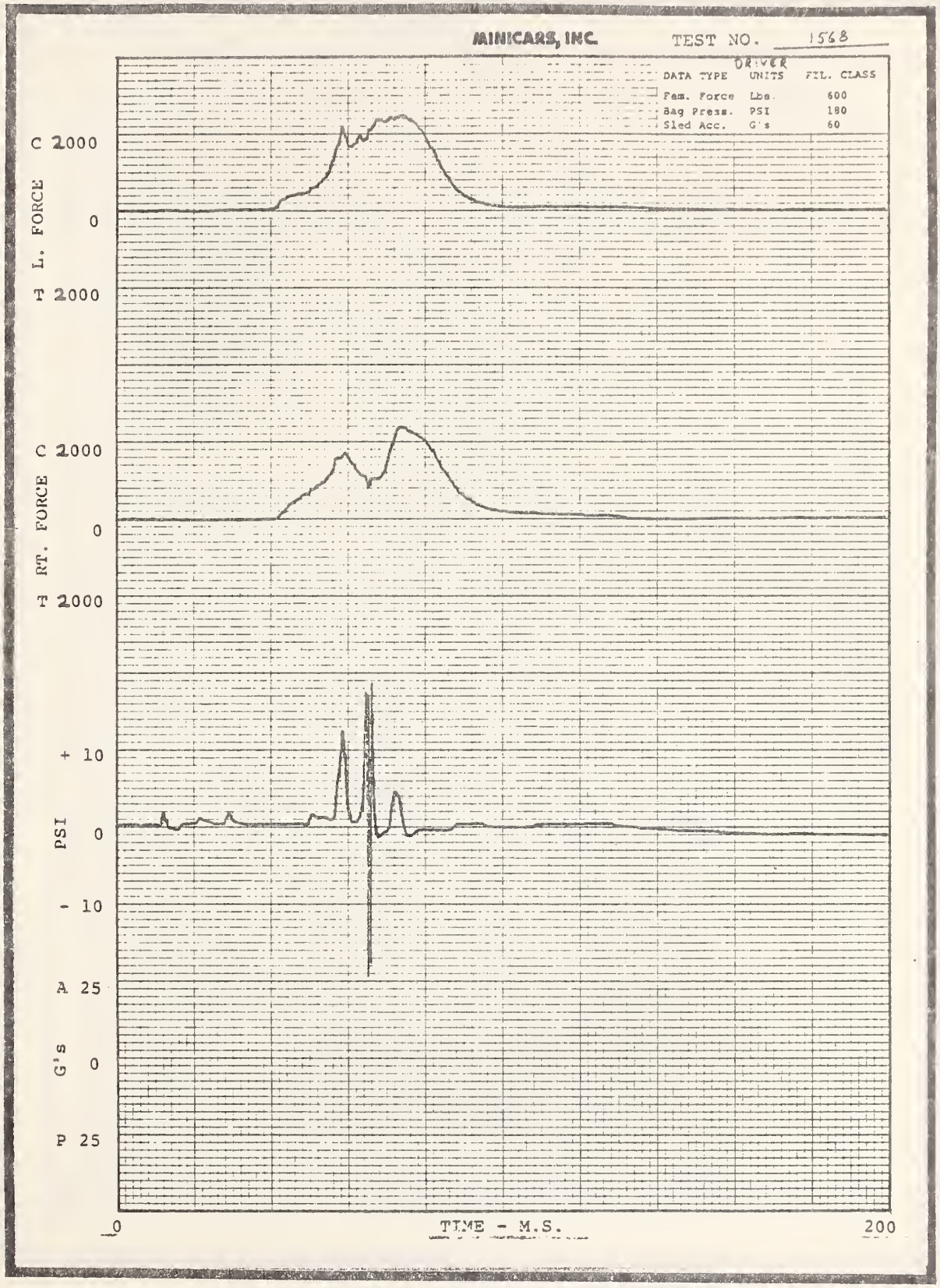

MINICARS, INC.
1555
RMC
F.C. 60
A 40
G's 0
P 40
R 40
G's 0
L 40
0
TIME - MS
200

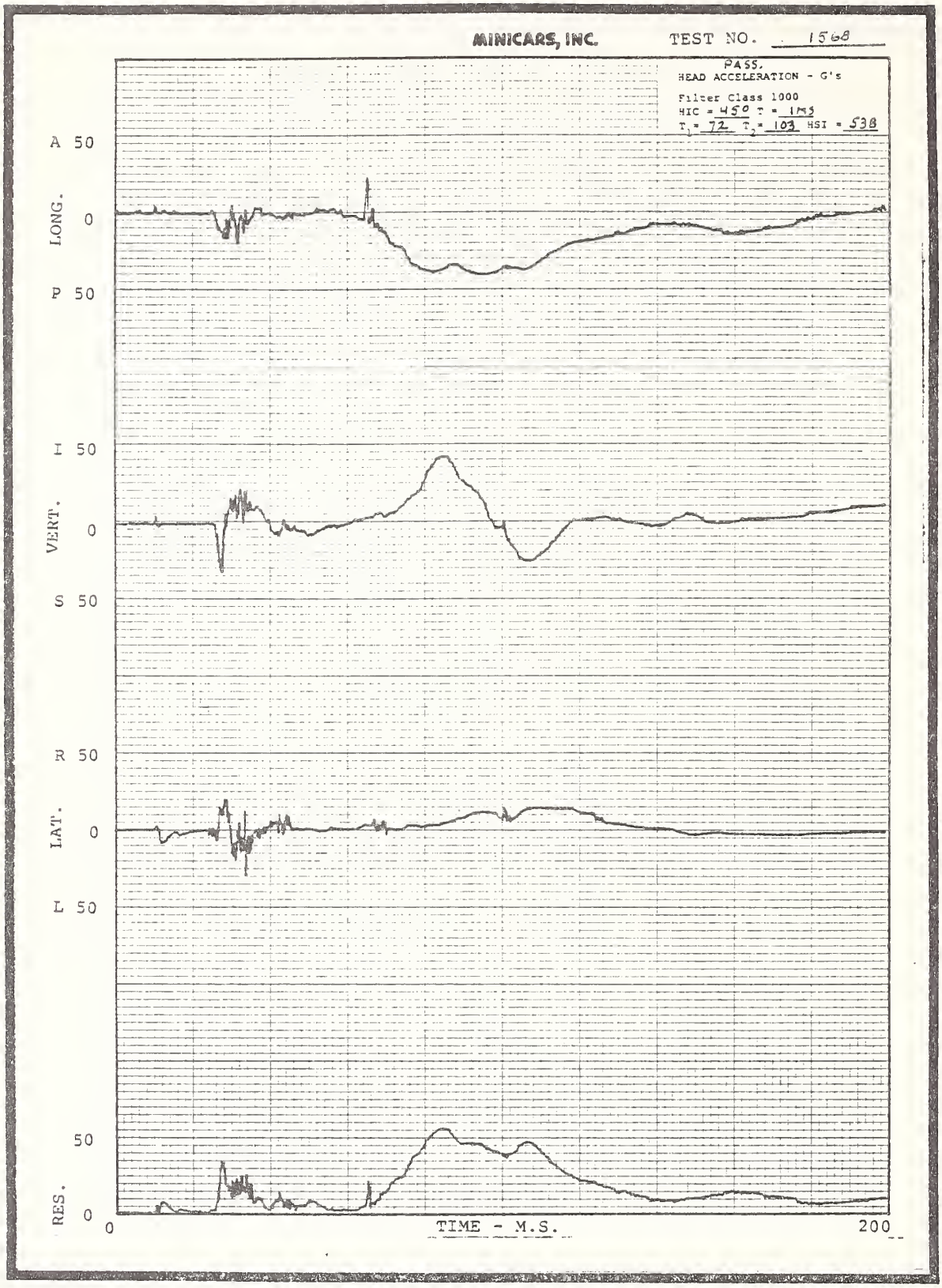

MINICARS, INC.
1555
RMC (A-P)
1ST ∫
2ND ∫
FC. 180
A 40
G's
0
P 40
40
FPS
0
20
IN
0
0
TIME - m.S.
200

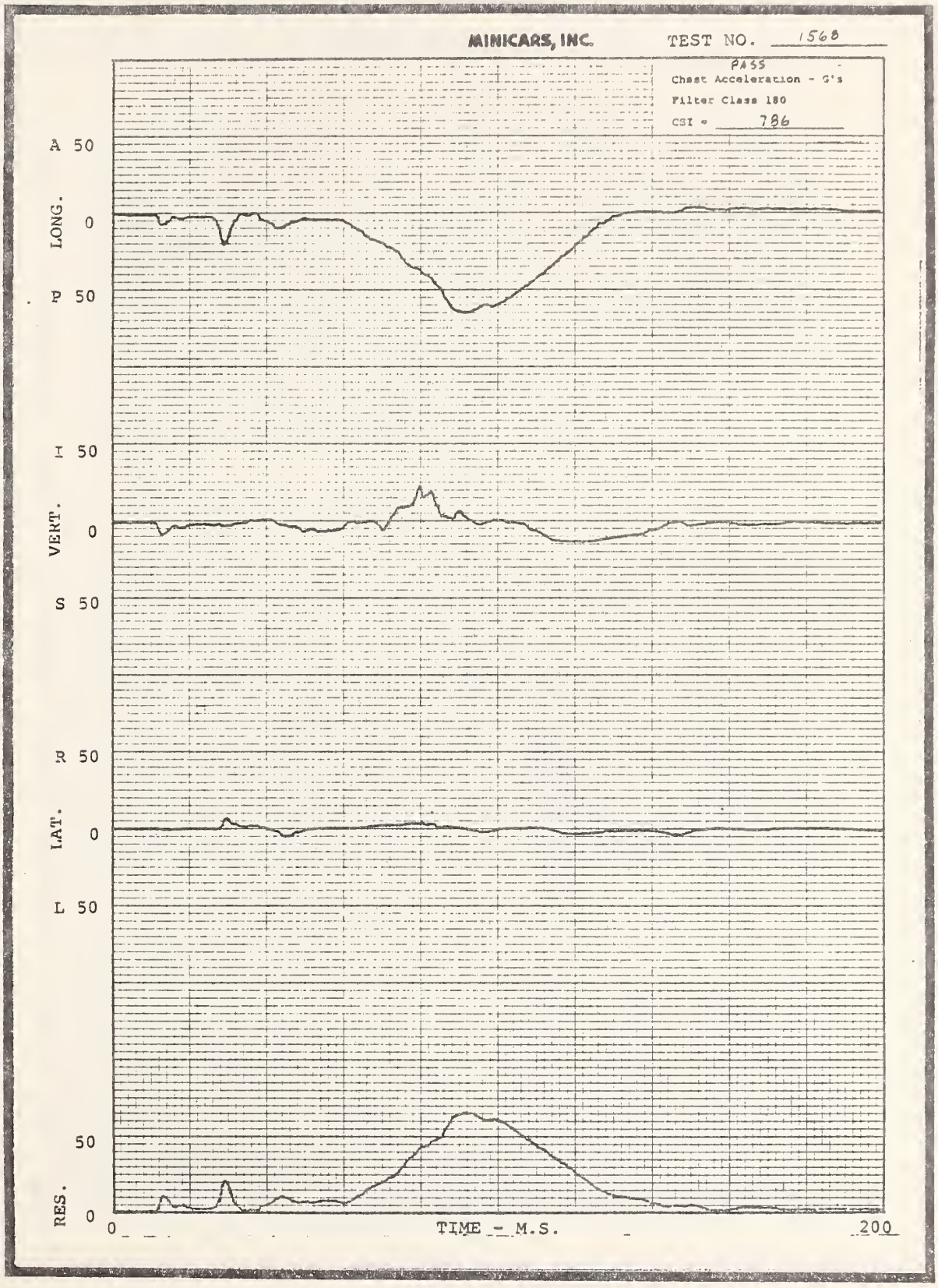

MINICARS, INC.
1555
FC = 1000
SAVIB
2.0
0
TIME - MS
200

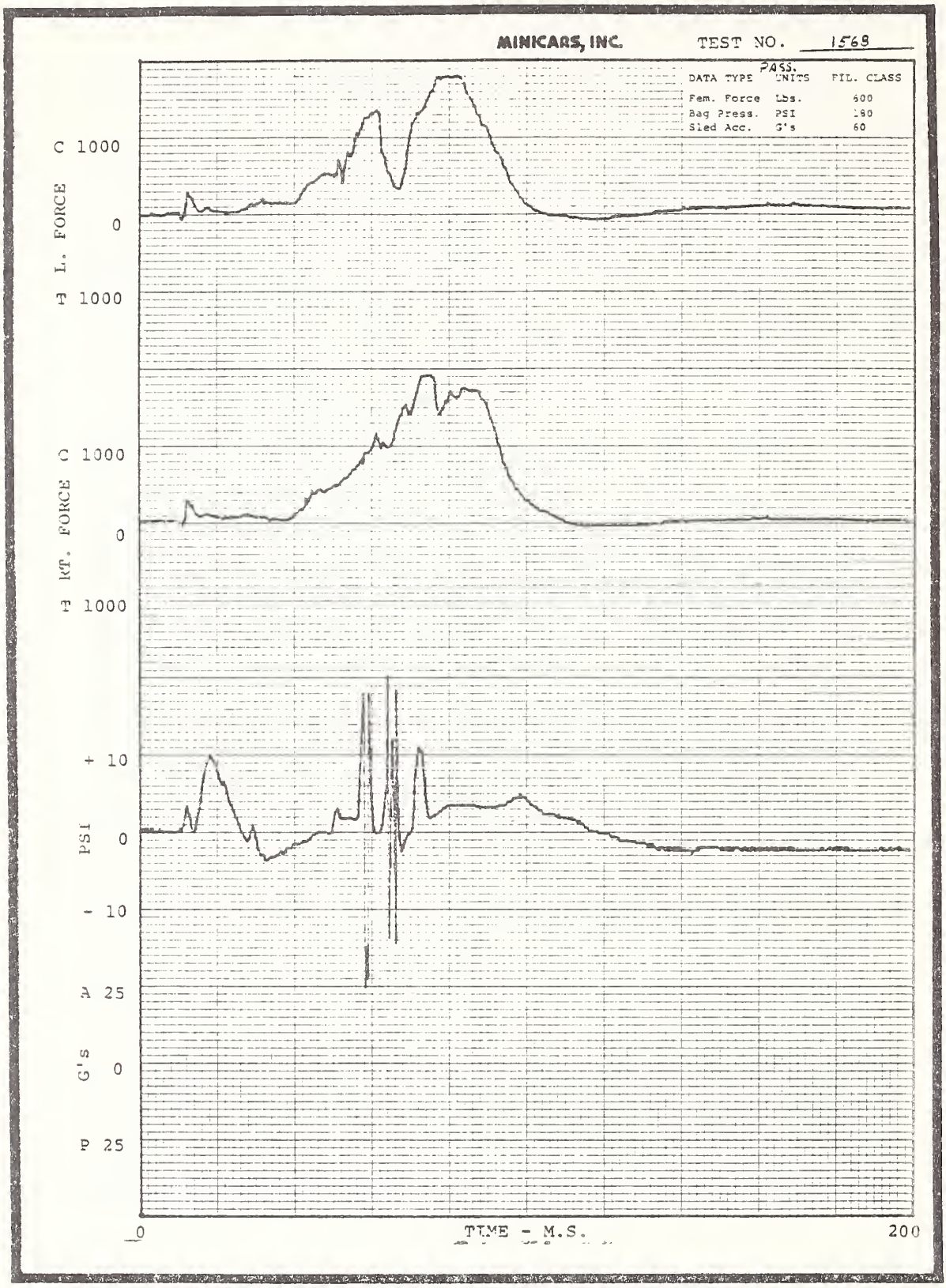

MINICARS, INC.
TEST NO. 1568
DVR
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 552 T = 1MS
T1 = 41 T2 = 111 HSI = 674
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

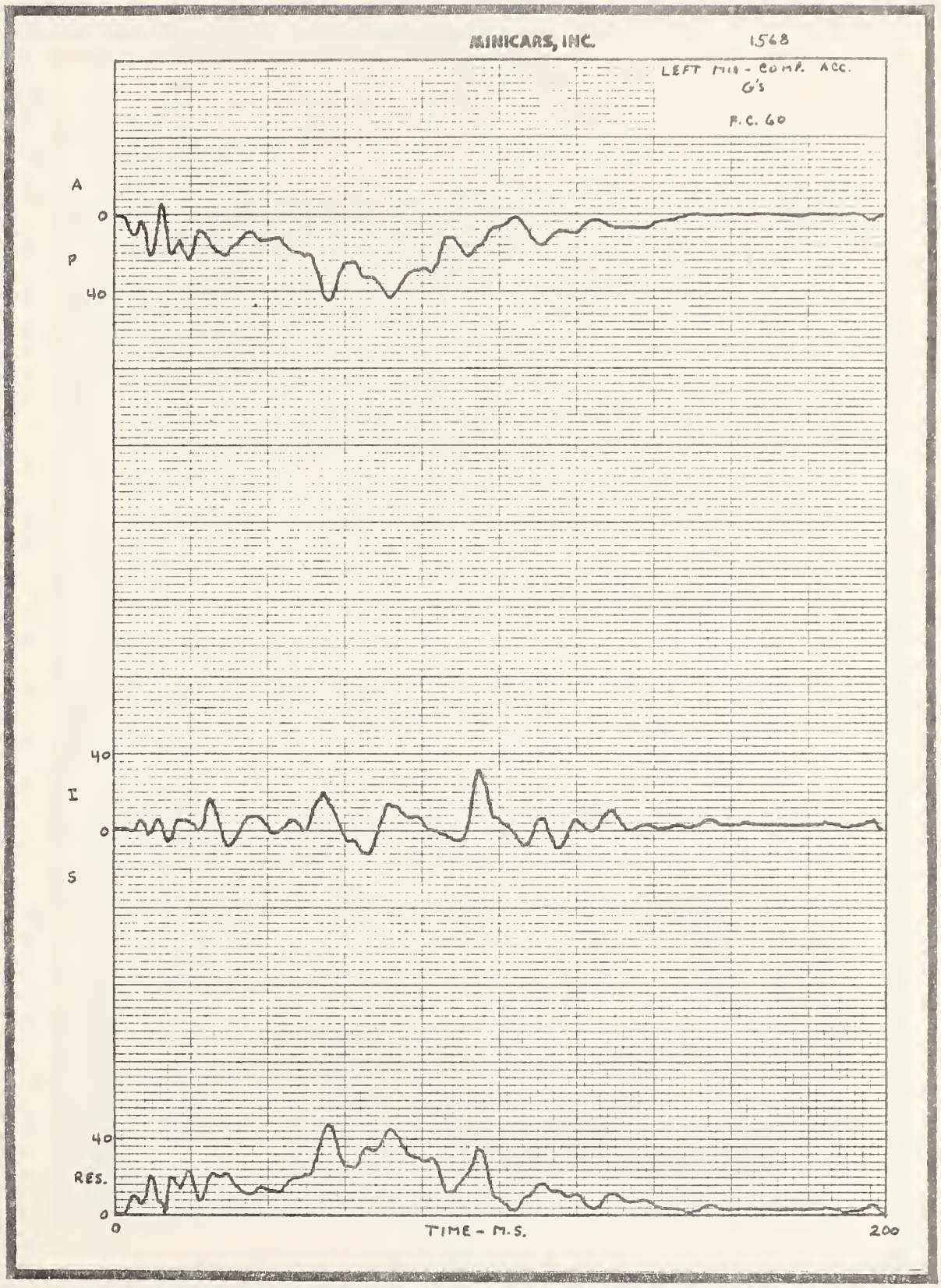

MINICARS, INC.
TEST NO. 1568
DVR.
Chest Acceleration - G's
Filter Class 180
CSI = <850
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
CSI TO BE RECALCULATED G.T.
AFTER FAIRING OF LARGE
NOISE SPIKE
50
RES.
0
0
TIME - M.S.
200

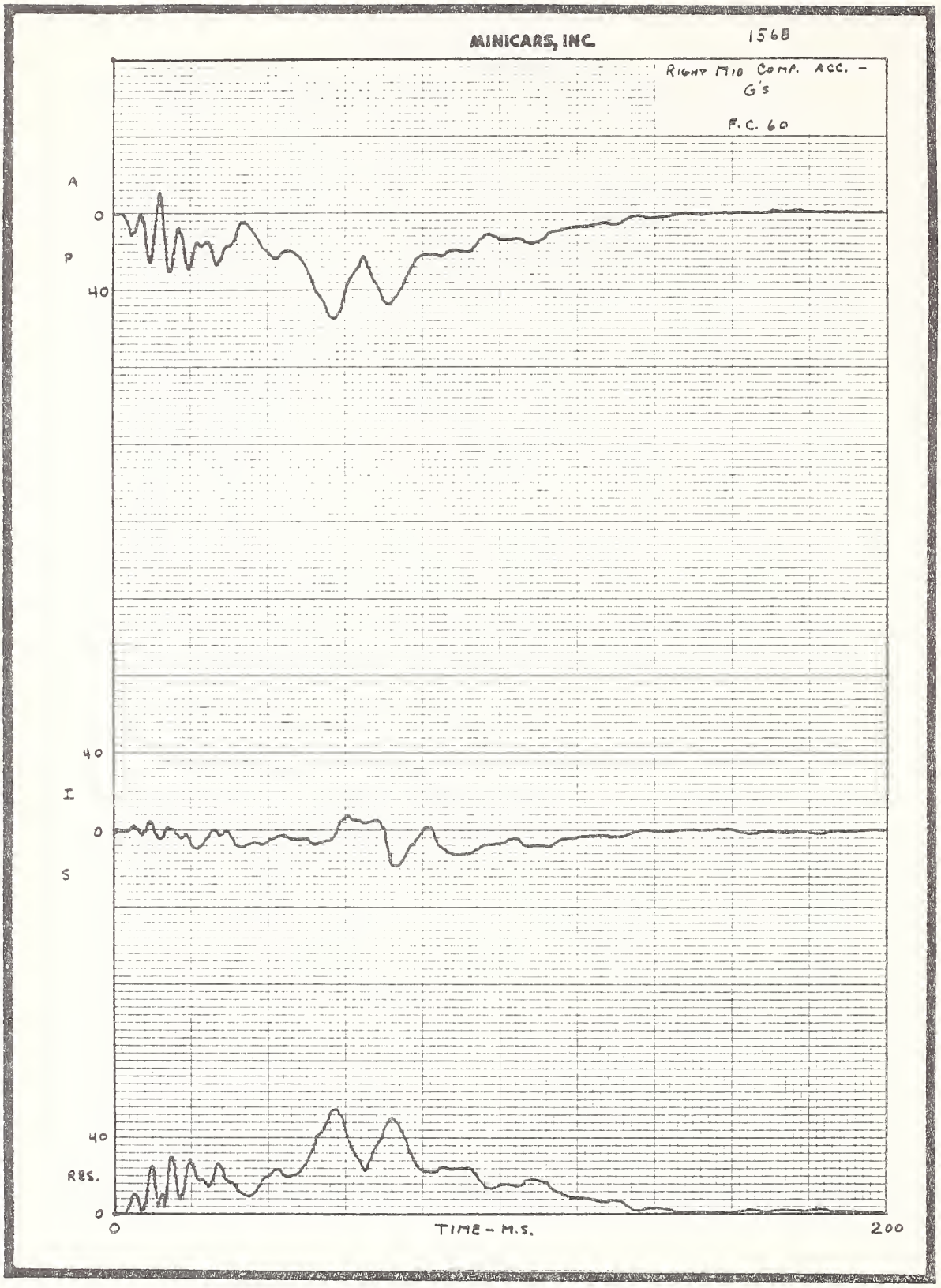

MINICARS, INC.
TEST NO. 1568
DRIVER
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

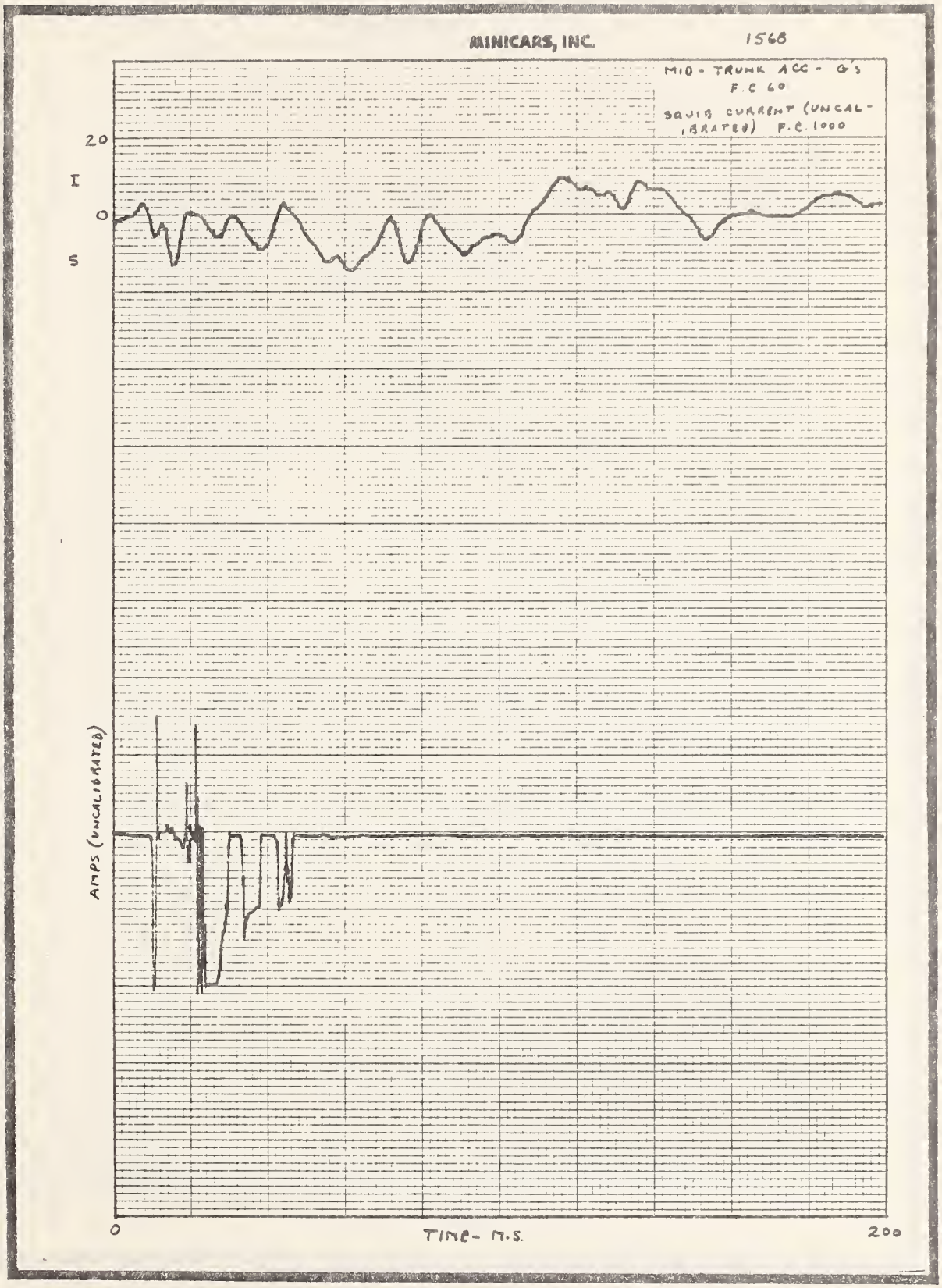

MINICARS, INC.
TEST NO. 1568
PASS.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 450 T = 1MS
T1 = 72 T2 = 103 HSI = 538
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

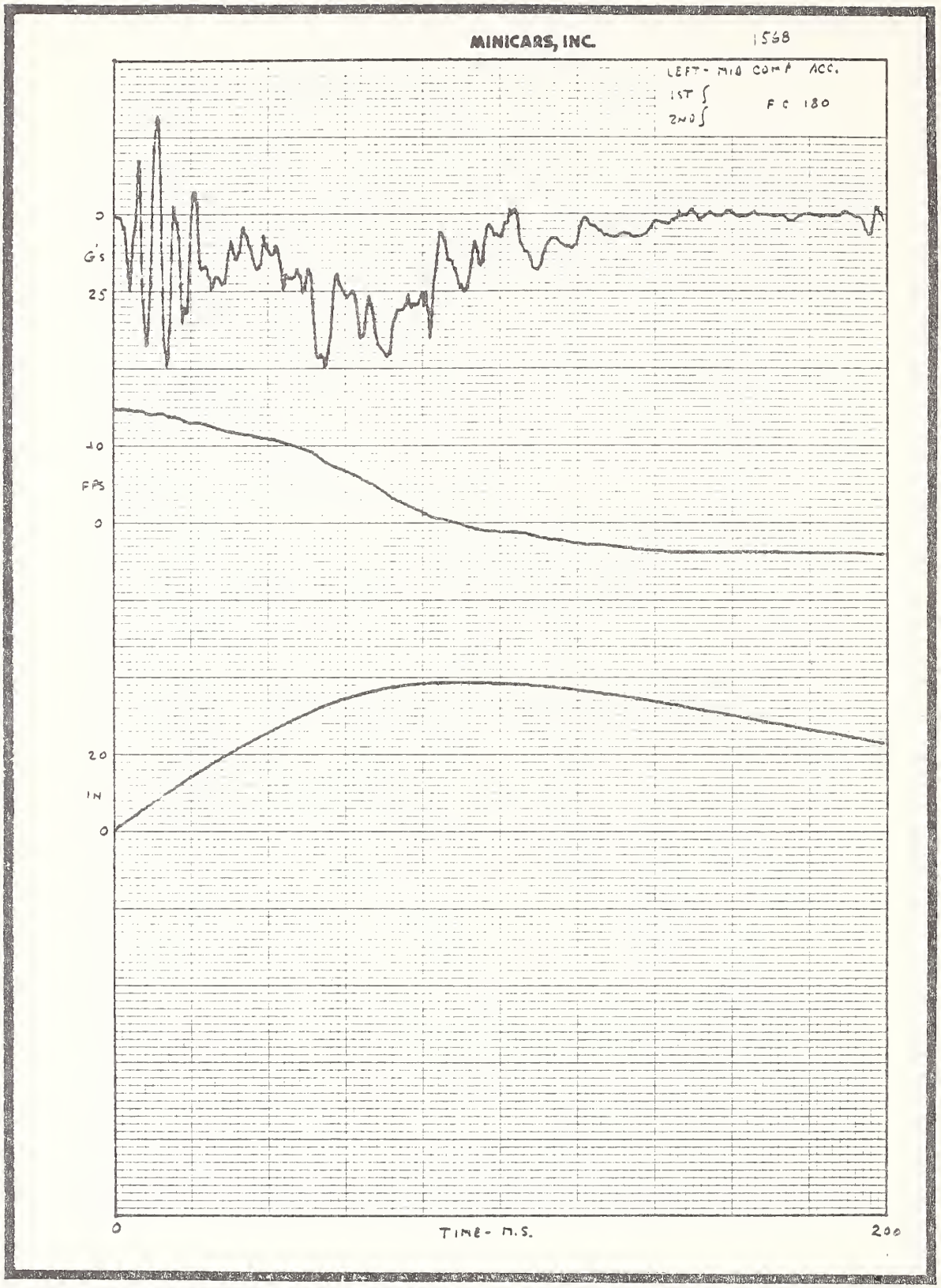

MINICARS, INC.
TEST NO. 1568
PASS
Chest Acceleration - G's
Filter Class 180
CSI = 786
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

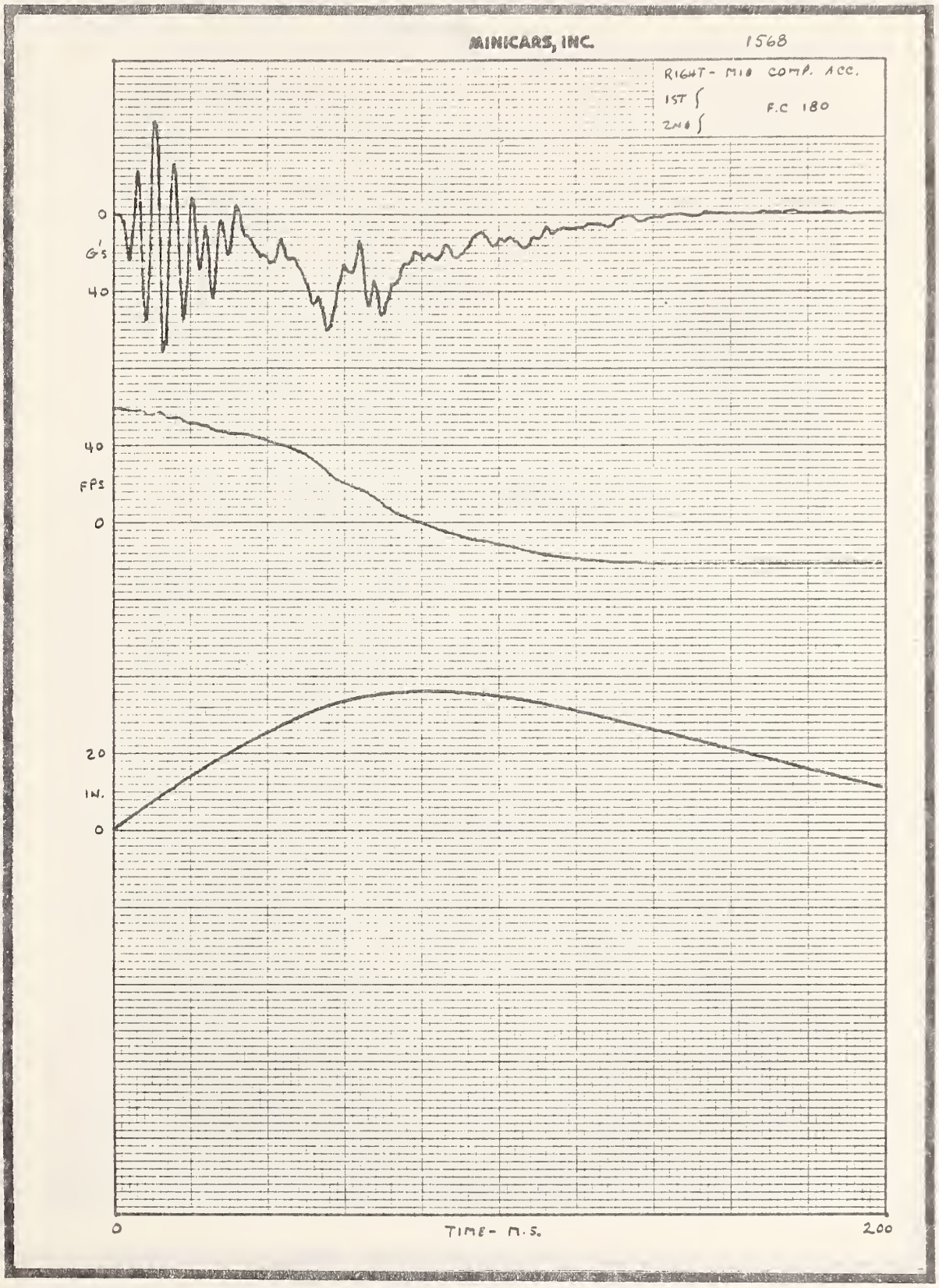

MINICARS, INC.
TEST NO. 1568
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
L. FORCE
T 1000
C 1000
RT. FORCE
0
T 1000
+ 10
PSI
0
- 10
A 25
G'S
0
P 25
0
TIME - M.S.
200

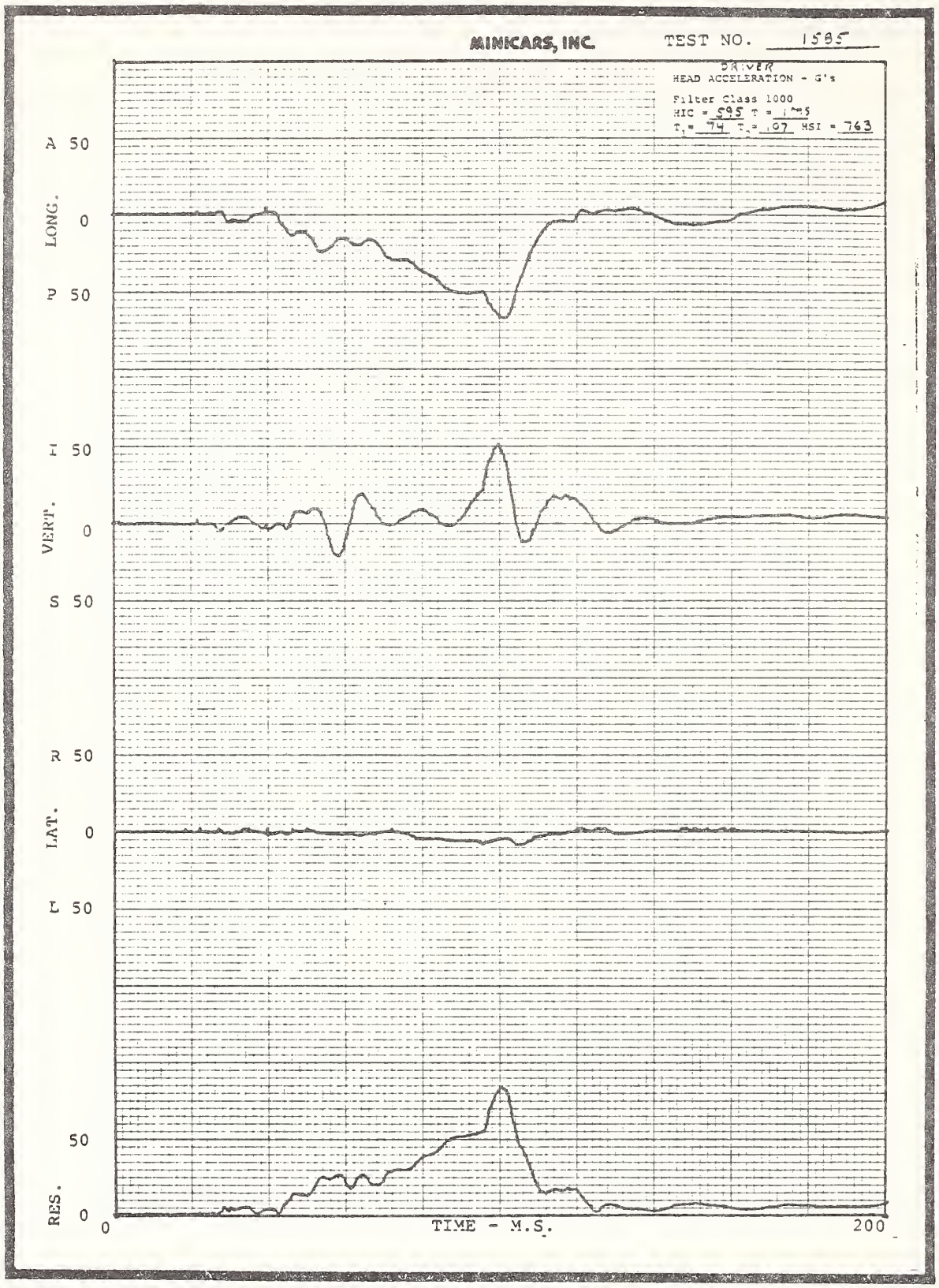

MINICARS, INC.
1568
LEFT MID - COMP. ACC.
G's
F.C. 60
A
P
0
40
I
S
40
0
RES.
40
0
0
TIME - M.S.
200

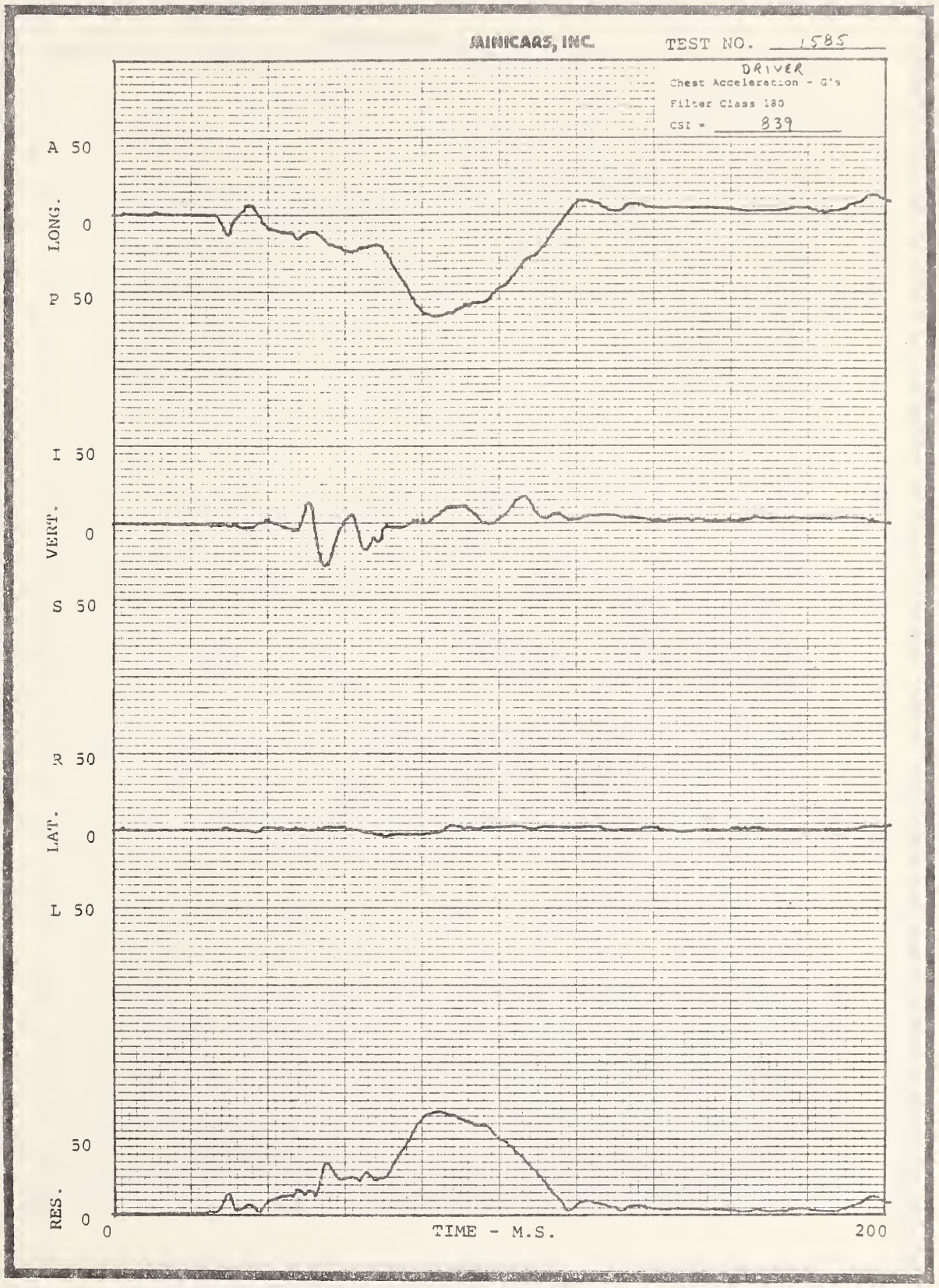

MINICARS, INC.
1568
RIGHT MID COMP. ACC. - G's
F.C. 60
A
P
0
40
40
I
S
0
40
RES.
0
0
TIME - M.S.
200

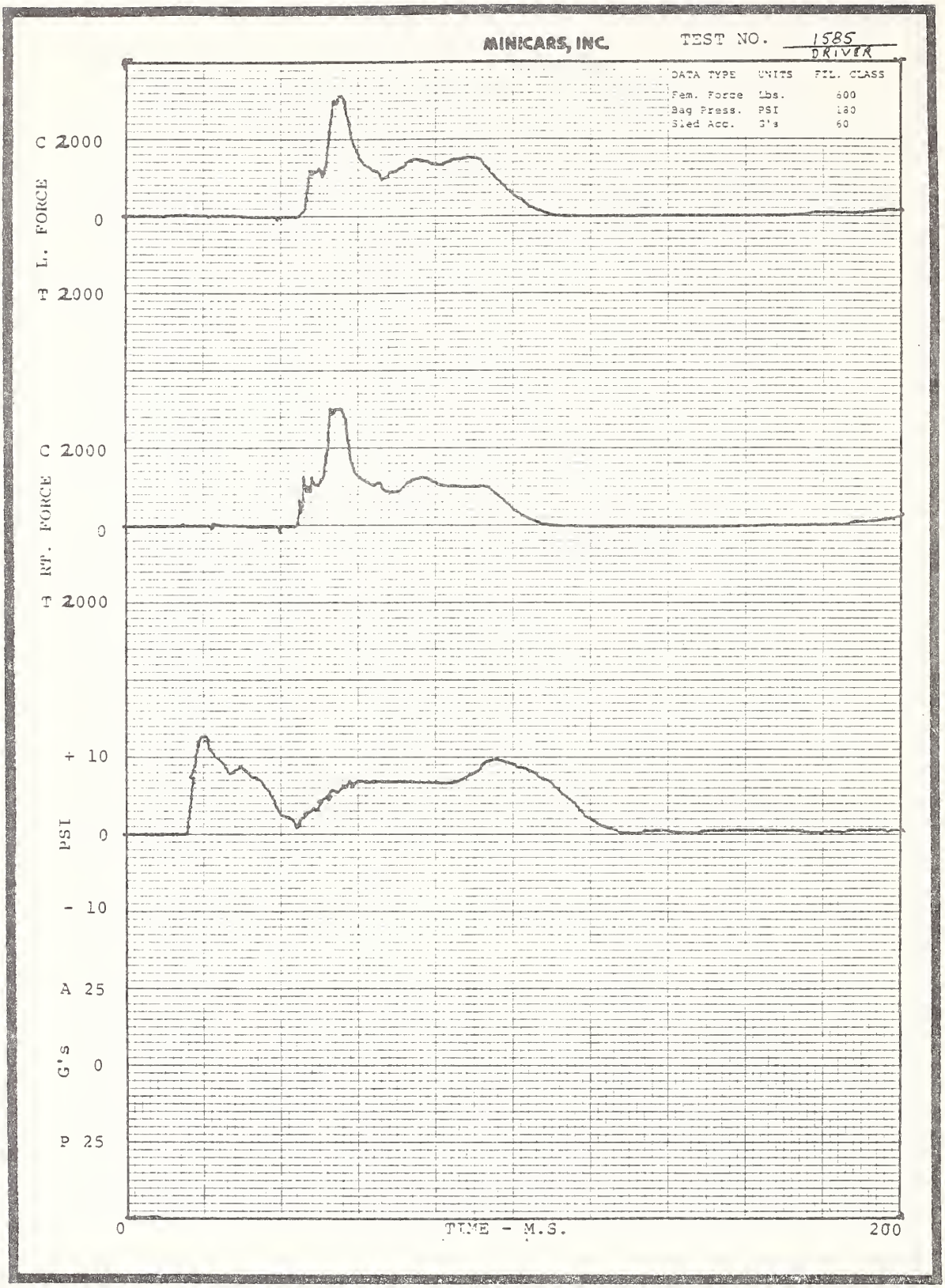

MINICARS, INC.
1568
MID - TRUNK ACC - G'S
F.C 60
SQUIB CURRENT (UNCALIBRATED) F.C 1000
20
I
0
S
AMPS (UNCALIBRATED)
0
TIME - M.S.
200

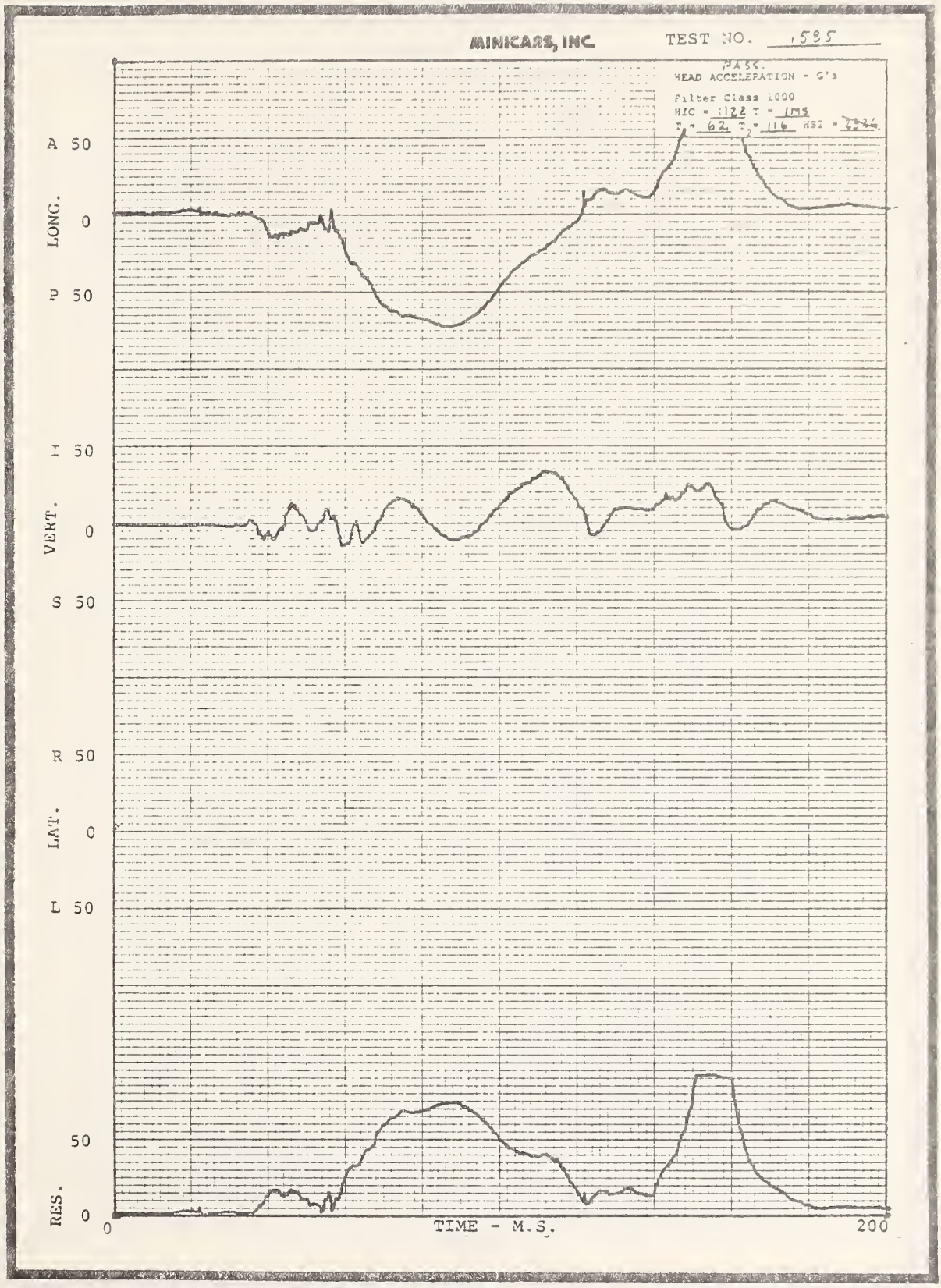

MINICARS, INC.
1568
LEFT - MID COMP ACC.
1ST
2ND
F C 180
0
G's
25
10
FPS
0
20
IN
0
0
TIME - M.S.
200

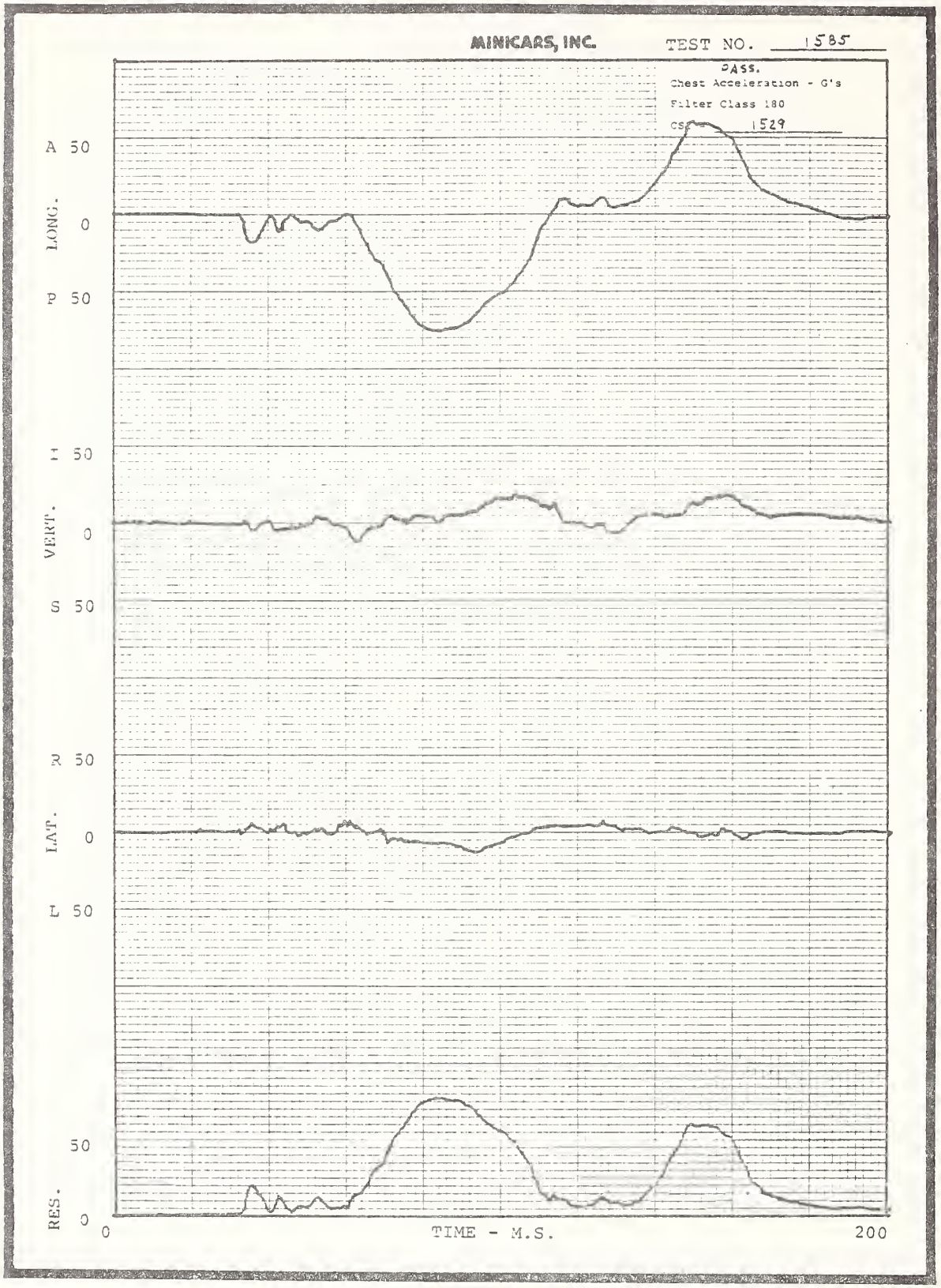

MINICARS, INC.
1568
RIGHT - M18 COMP. ACC.
1ST ∫
2ND ∫
F.C 180
0
G's
40
40
FPS
0
20
IN.
0
0
TIME - M.S.
200

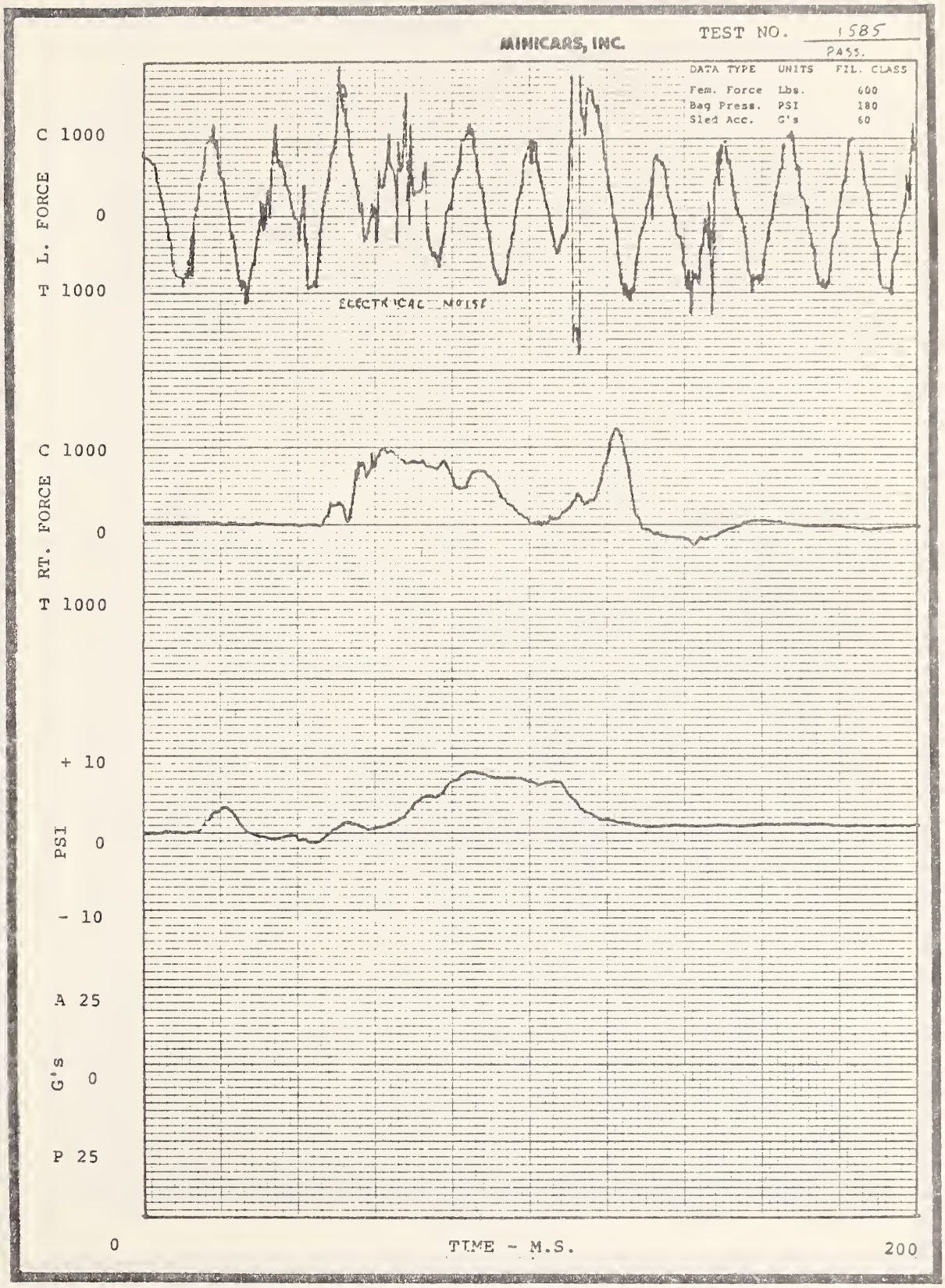

MINICARS, INC.
TEST NO. 1585
DRIVER
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 595 T = 1785
T1 = 74 T2 = 107 HSI = 763
A 50
LONG.
0
P 50
F 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

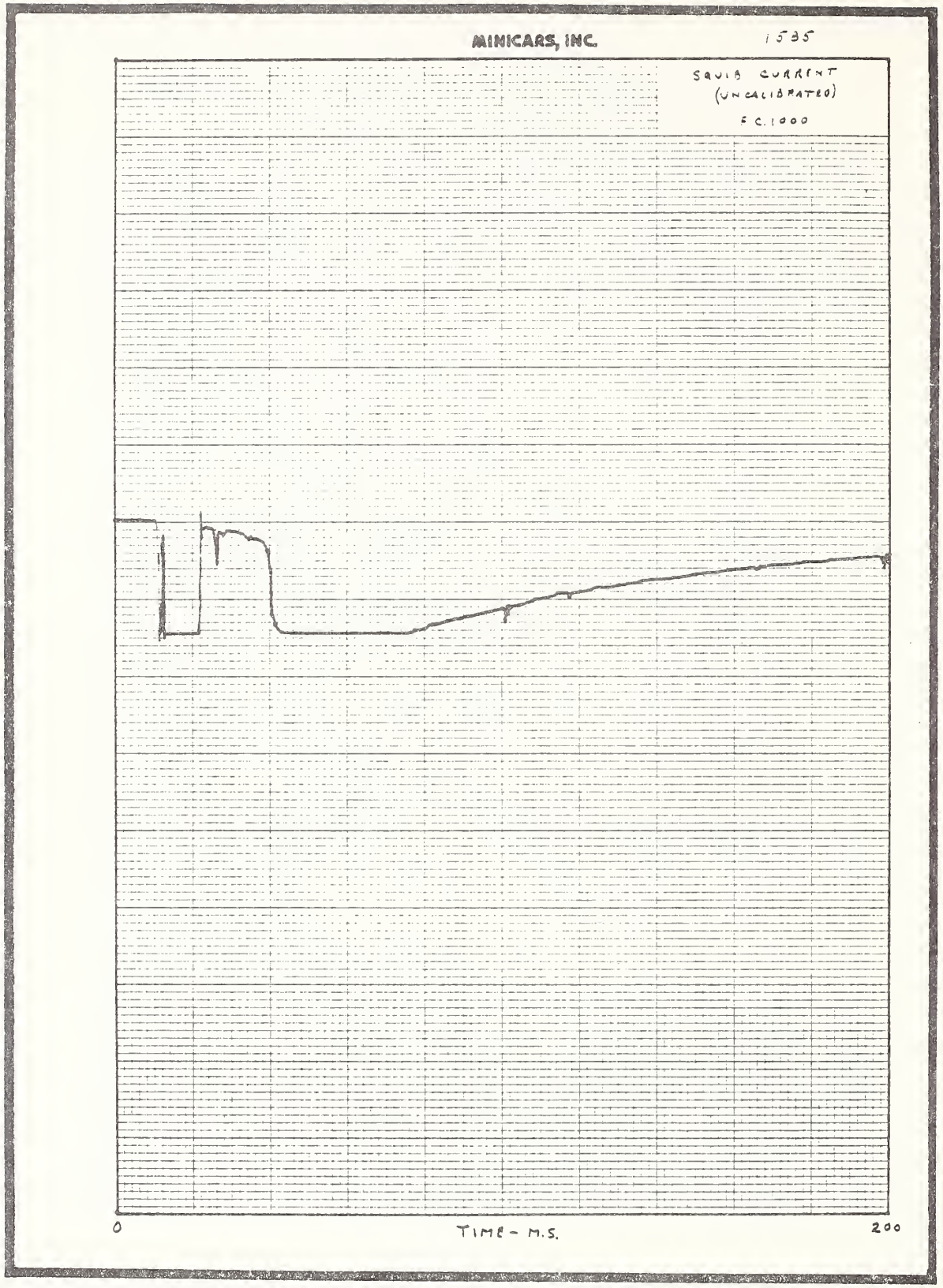

MINICARS, INC.
TEST NO. 1585
DRIVER
Chest Acceleration - G's
Filter Class 180
CSI = 839
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
TEST NO. 1585
DRIVER
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
0
T 2000
L. FORCE
C 2000
0
T 2000
RT. FORCE
+ 10
0
- 10
PSI
A 25
0
P 25
G's
0
TIME - M.S.
200

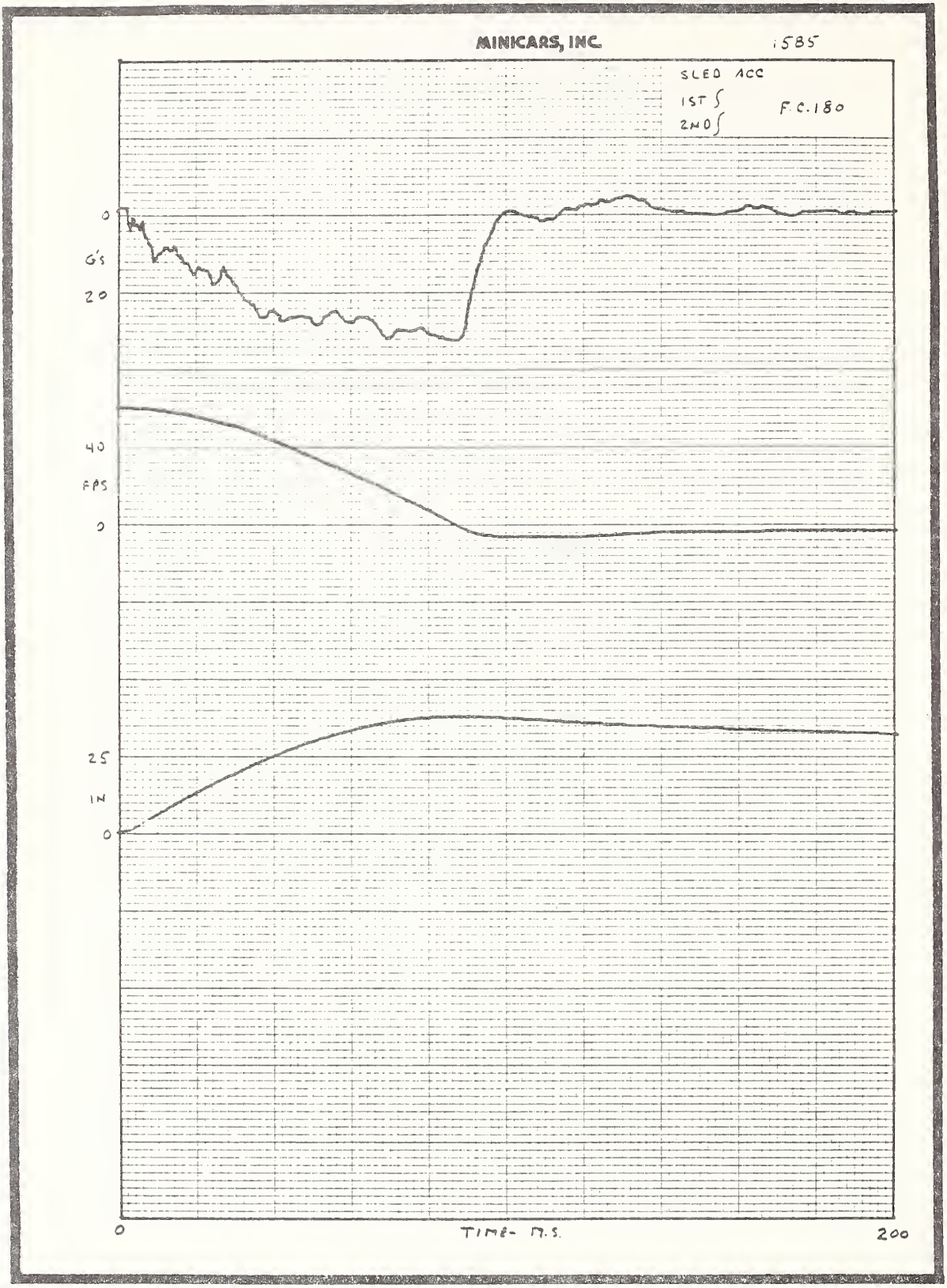

MINICARS, INC.
TEST NO. 1585
PASS.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 1122 T = 1MS
T = 62 T = 116 HSI =
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

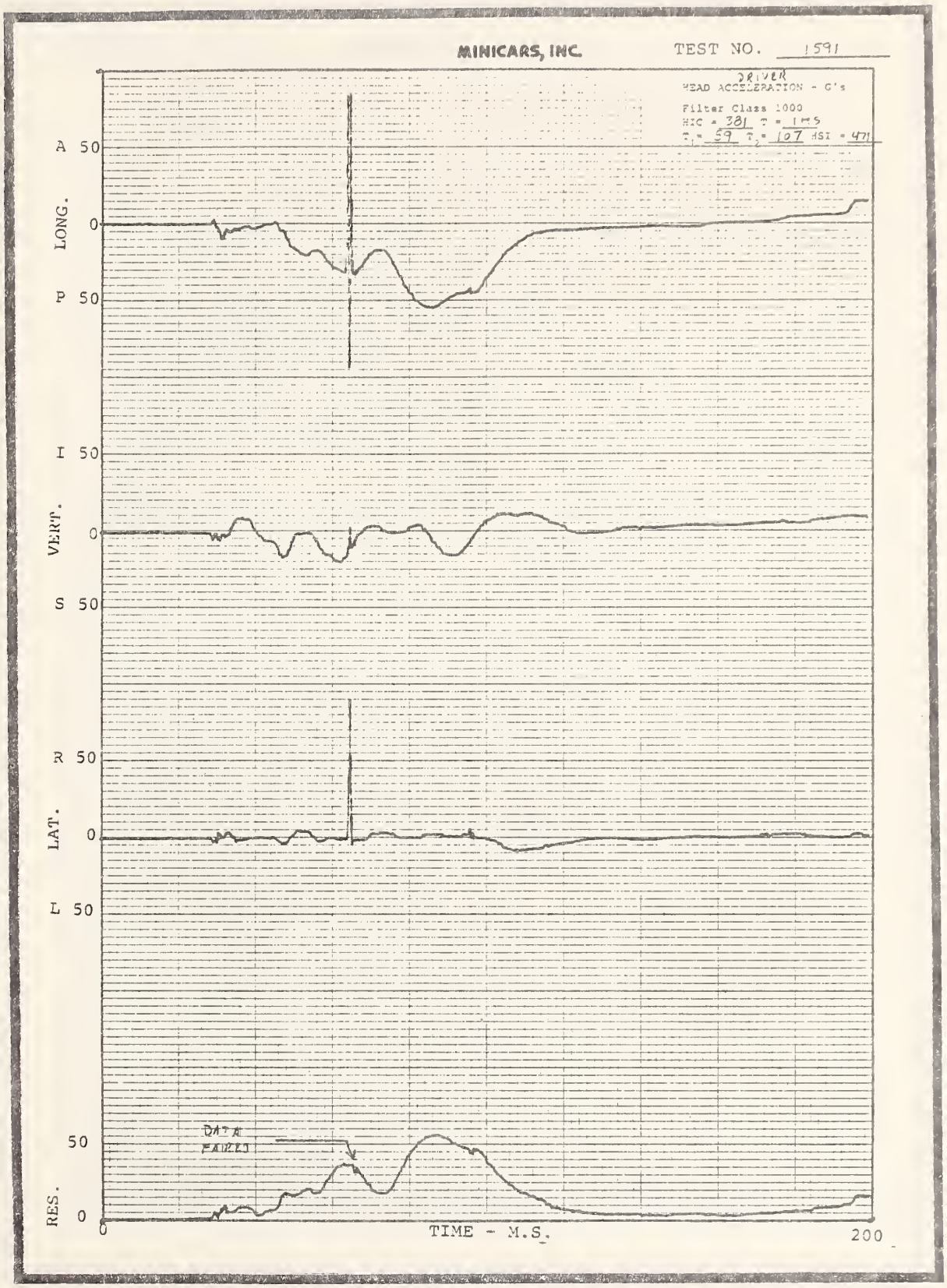

MINICARS, INC.
TEST NO. 1585
PASS.
Chest Acceleration - G's
Filter Class 180
CS 1529
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

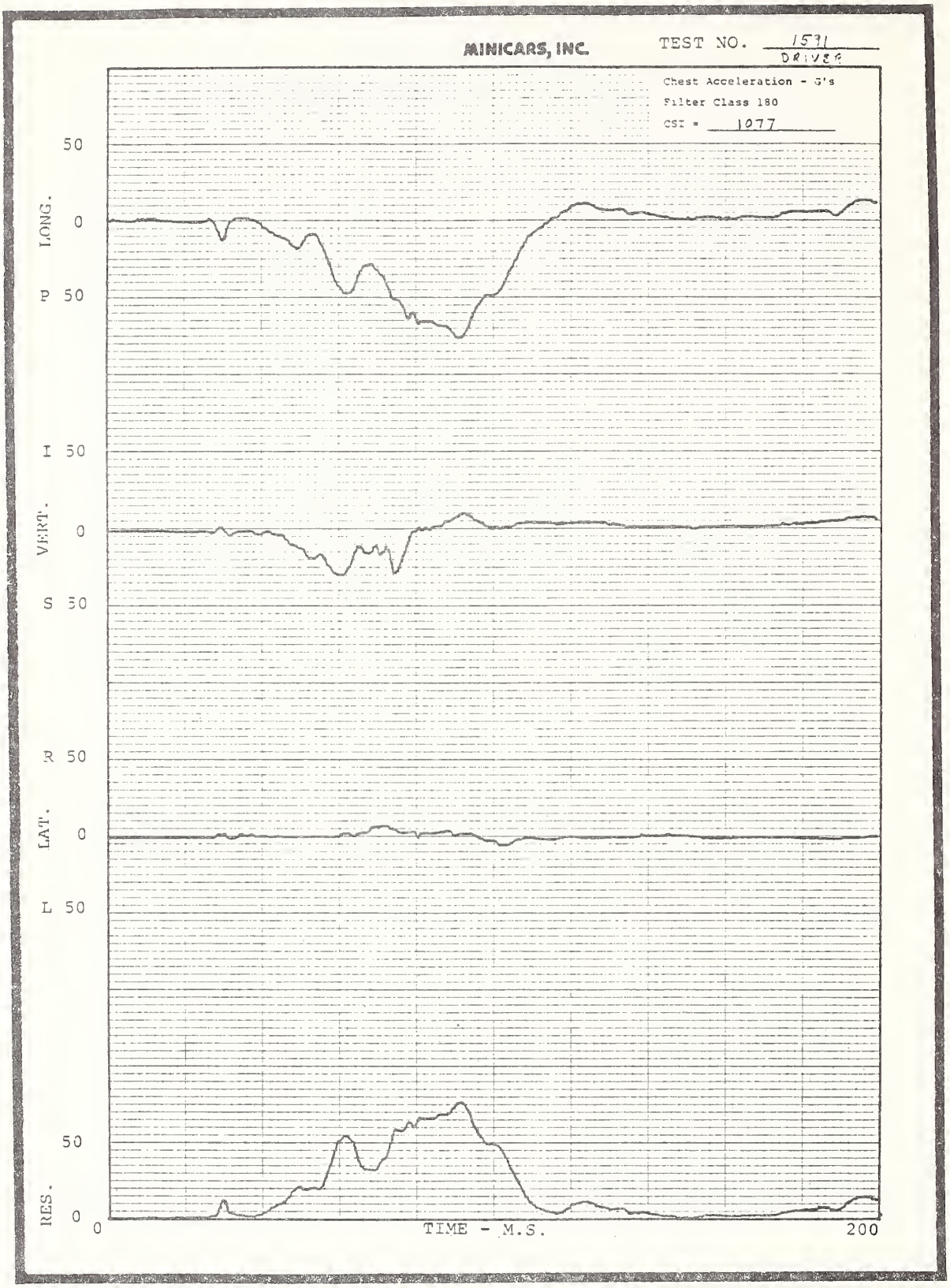

MINICARS, INC.
TEST NO. 1585
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
L. FORCE
0
T 1000
ELECTRICAL NOISE
C 1000
RT. FORCE
0
T 1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

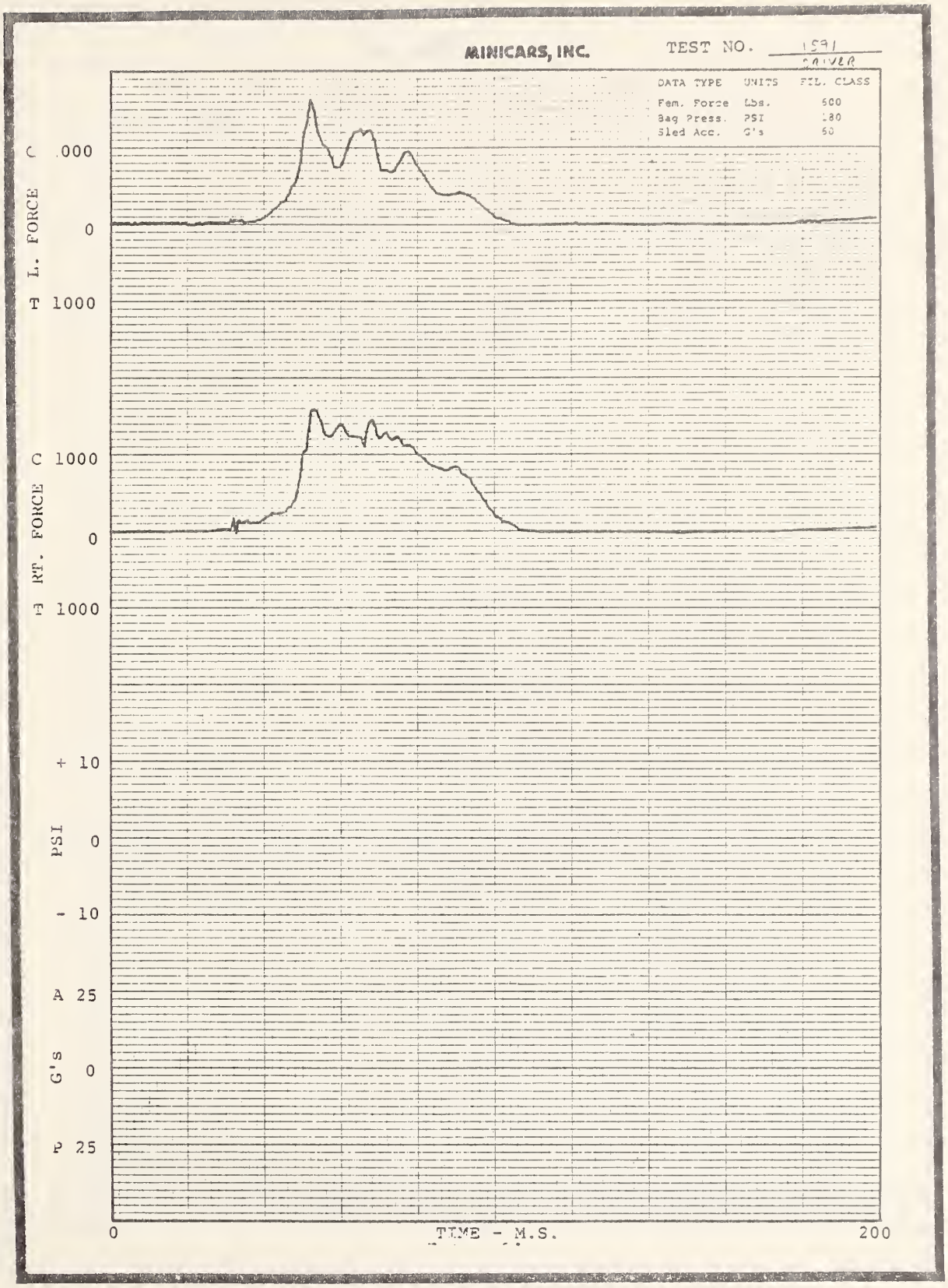

MINICARS, INC.
1535
SQUIB CURRENT
(UNCALIBRATED)
5 C.1000
0
TIME - M.S.
200

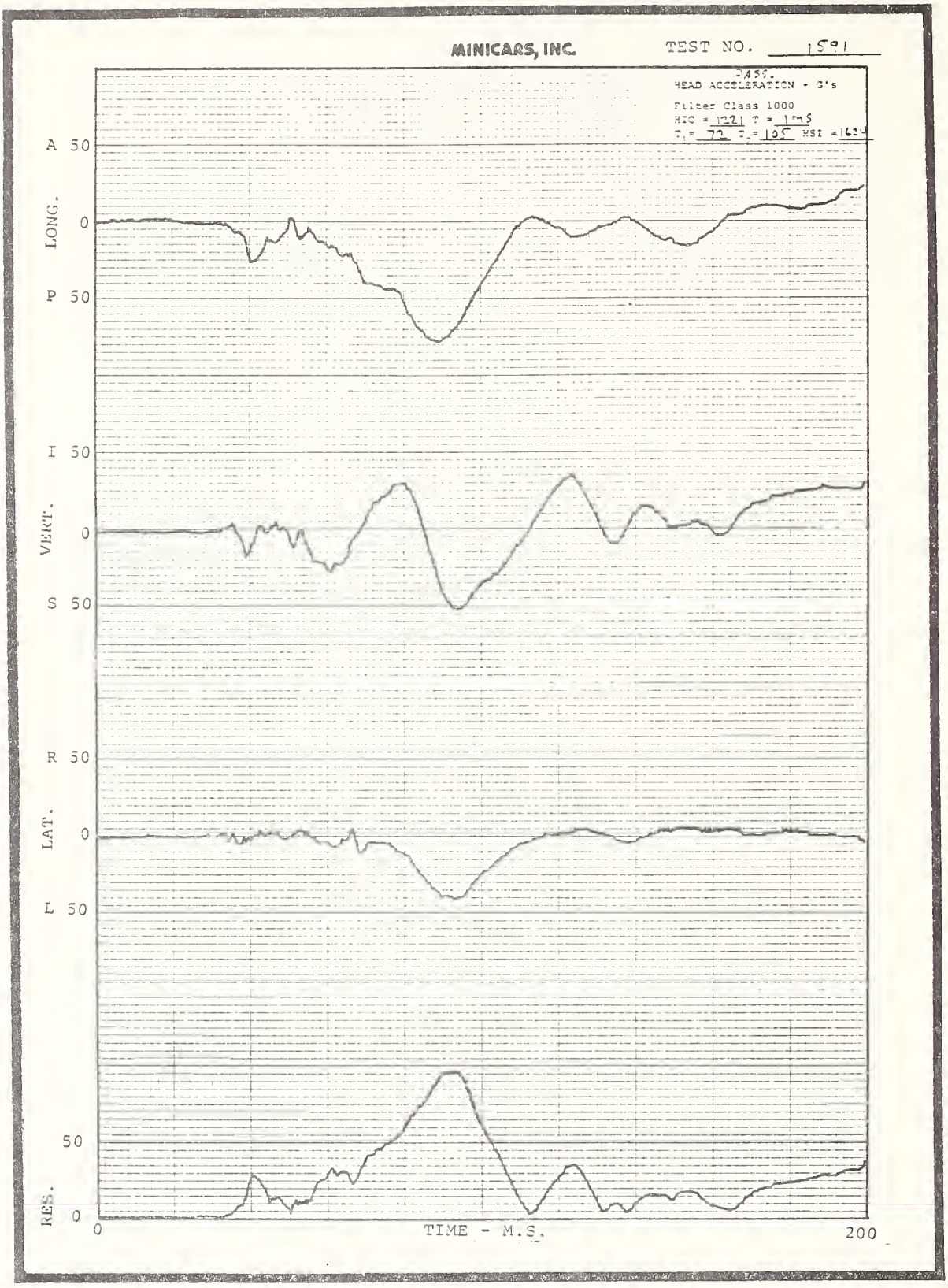
MINICARS, INC.
TEST NO. 1585
PASS
HEAD ACCELERATION - G's
Filter Class .000
HIC = T =
T1 = T2 = HSI =
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
ELECTRICAL NOISE
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

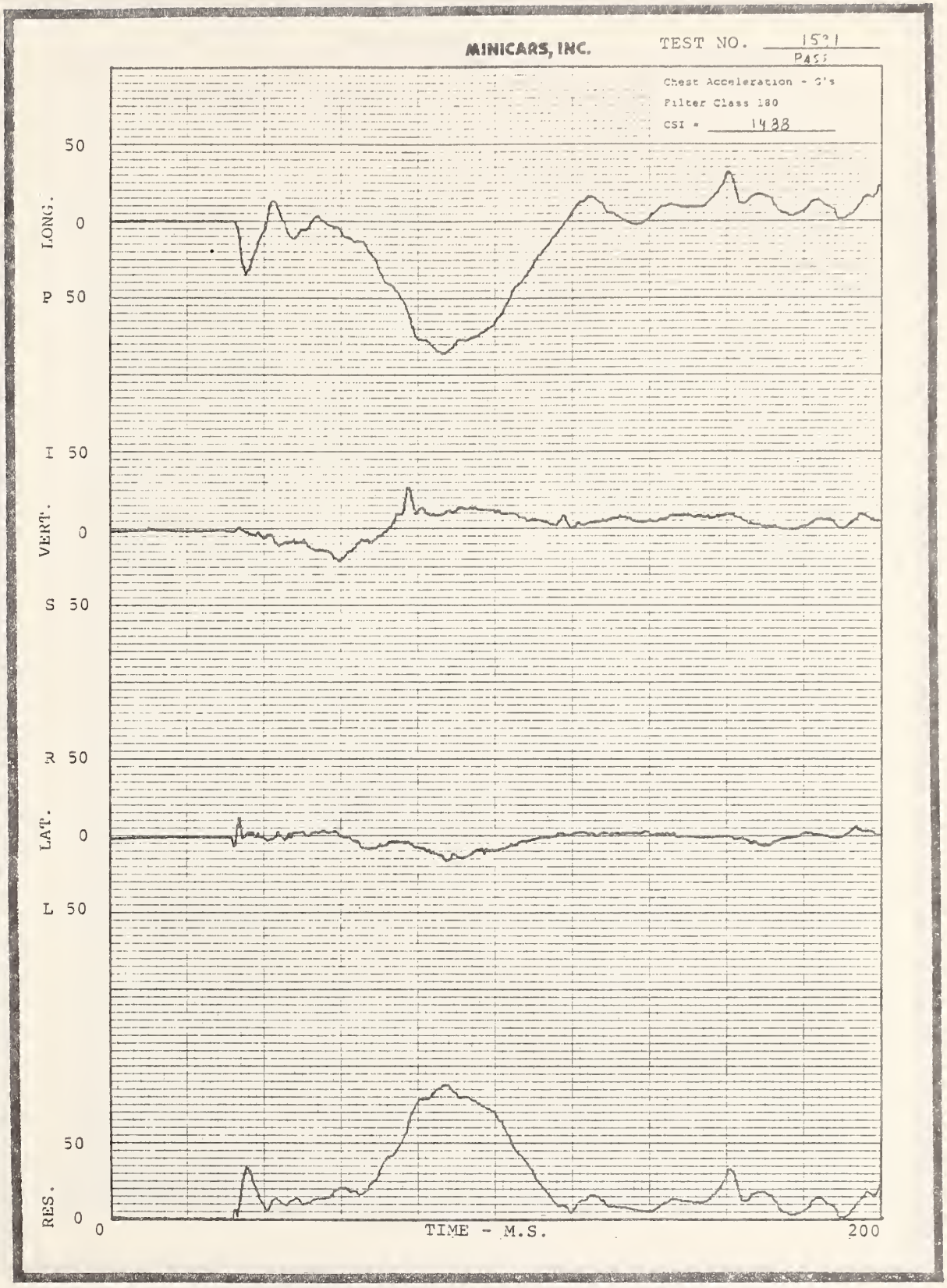

MINICARS, INC.
1585
SLED ACC
1ST ∫
2ND ∫
F.C.180
0
G's
20
40
FPS
0
25
IN
0
0
TIME- M.S.
200

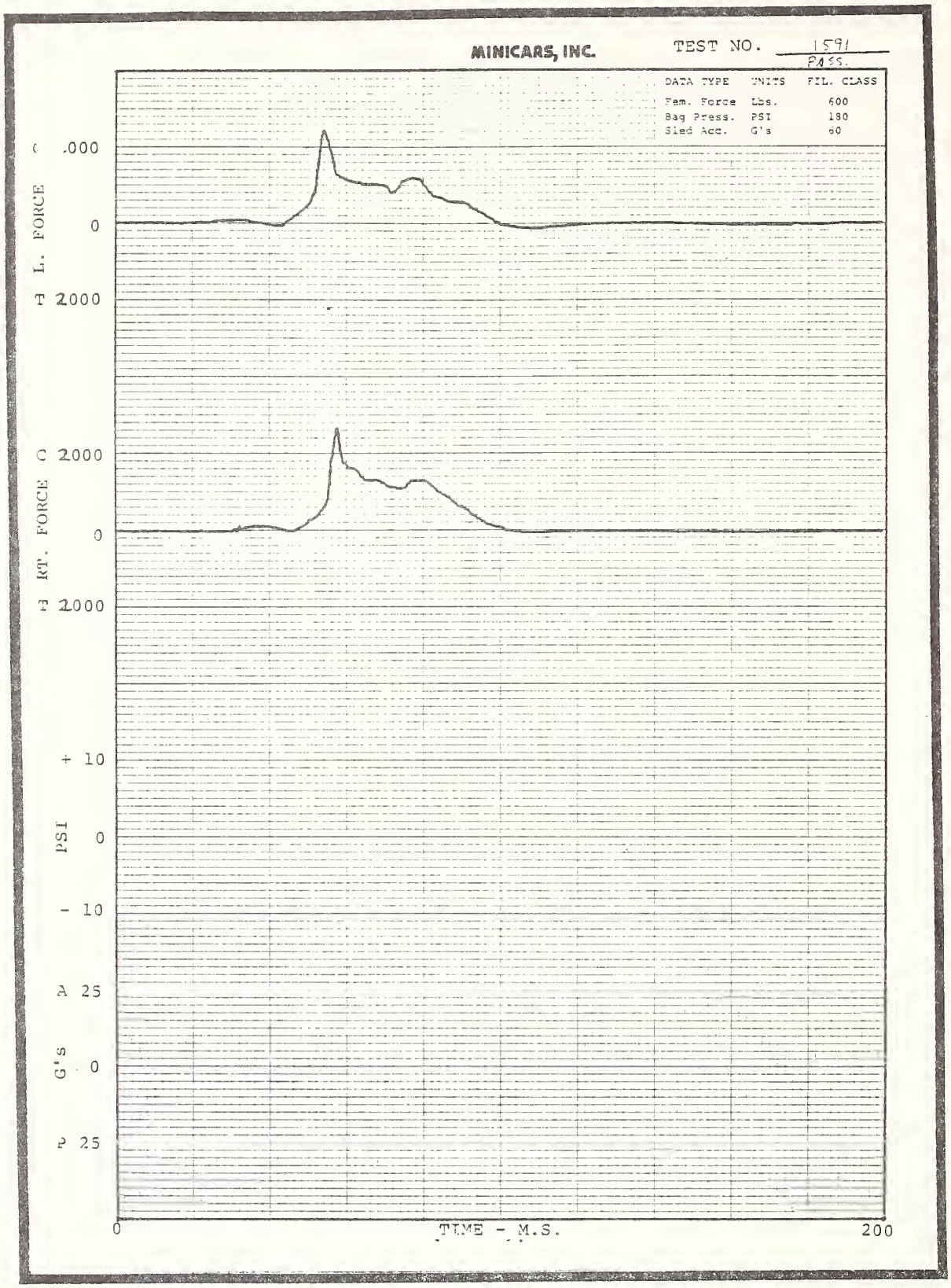

MINICARS, INC.
TEST NO. 1591
DRIVER
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 381 T = 1 MS
τ1 = 59 τ2 = 107 HSI = 471
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
DATA FAILED
0
TIME - M.S.
200

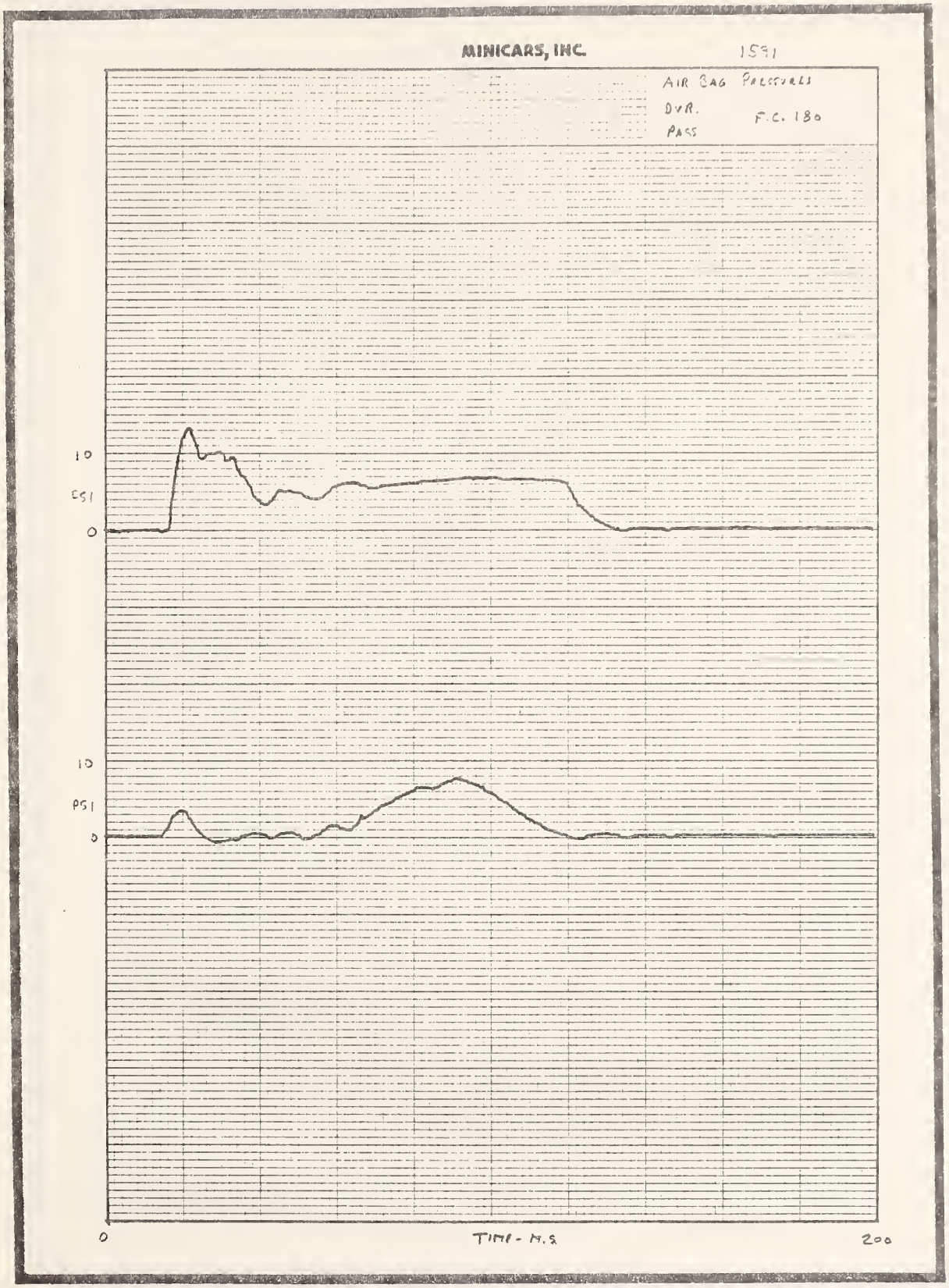

MINICARS, INC.
TEST NO. 1571
DRIVER
Chest Acceleration - G's
Filter Class 180
CSI = 1077
LONG.
P 50
0
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

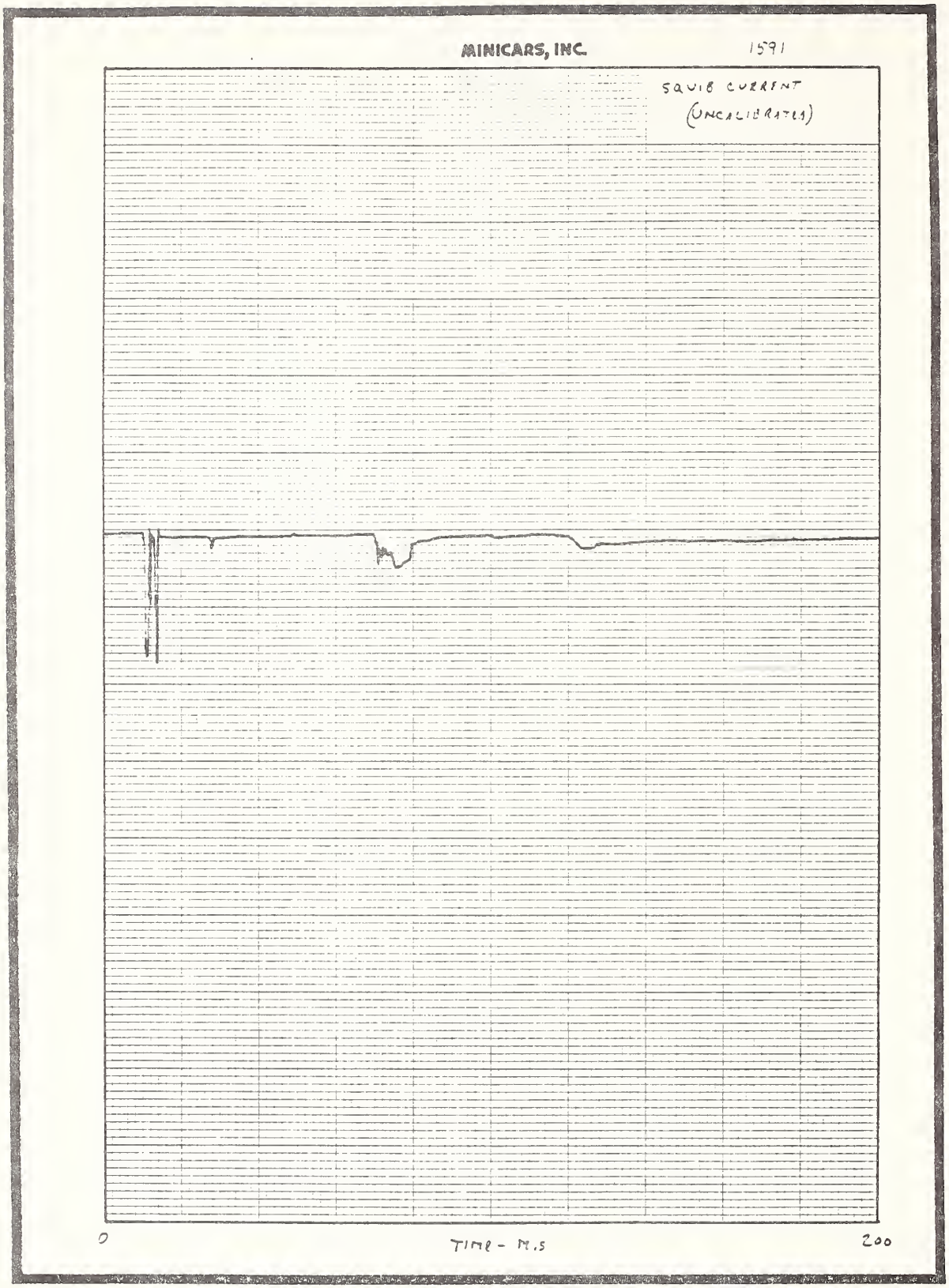

MINICARS, INC.
TEST NO. 1591
DRIVER
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C .000
T L. FORCE
0
T 1000
C 1000
T RT. FORCE
0
T 1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

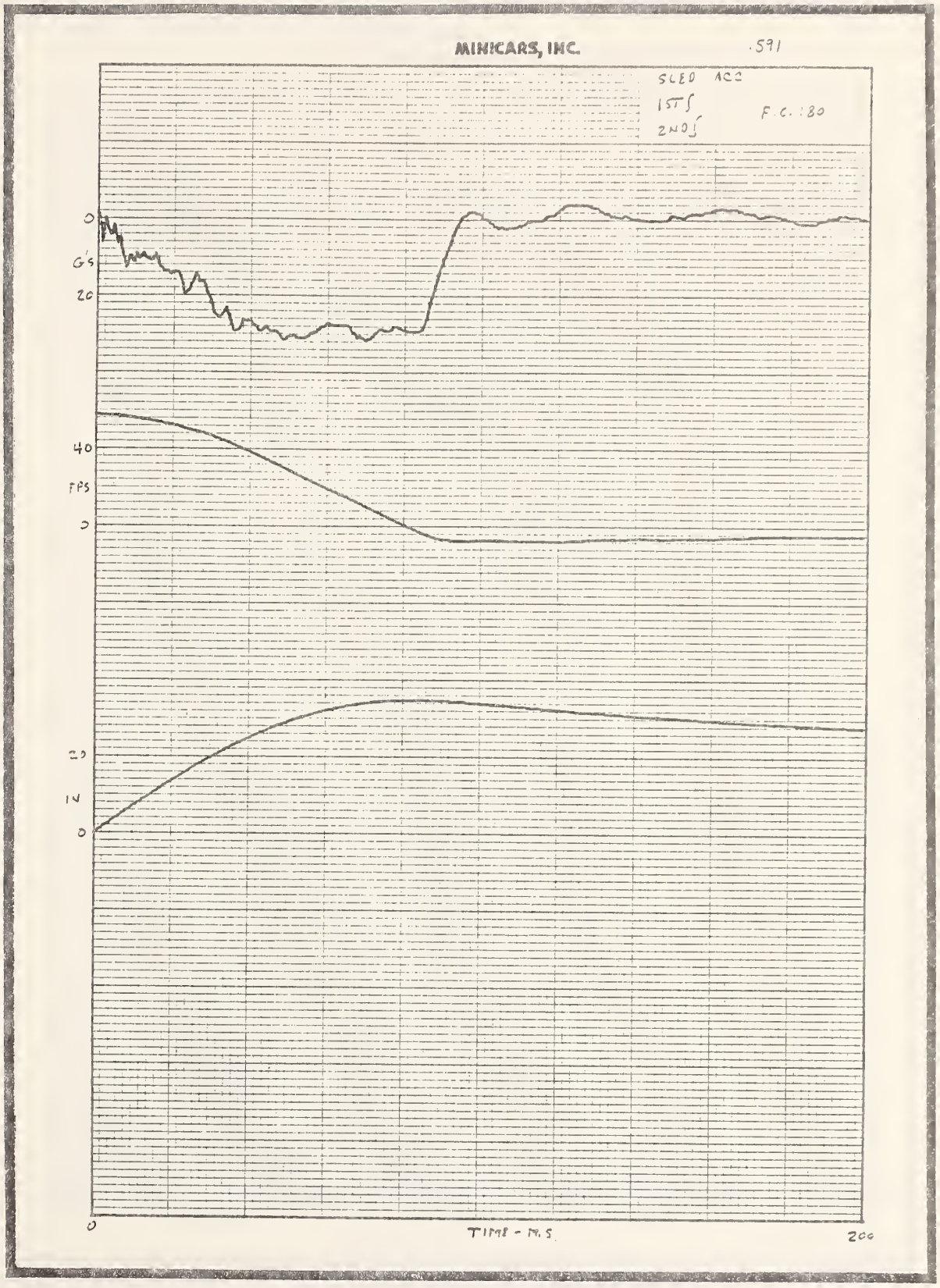

MINICARS, INC.
TEST NO. 1591
HEAD ACCELERATION - G's
Filter Class 1000
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

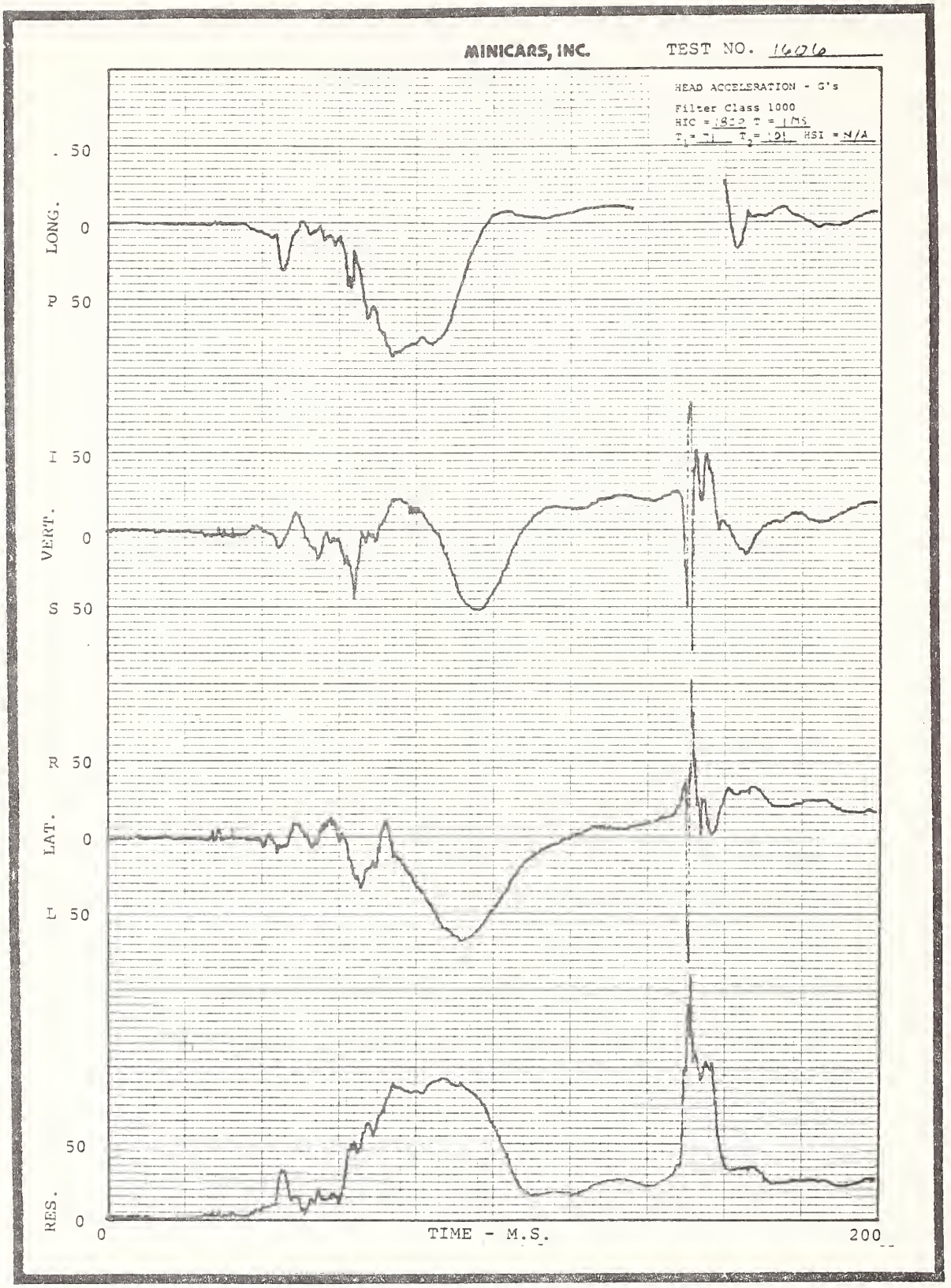

MINICARS, INC.
TEST NO. 1521
PASS
Chest Acceleration - G's
Filter Class 180
CSI = 1438
50
LONG.
0
P 50
H 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

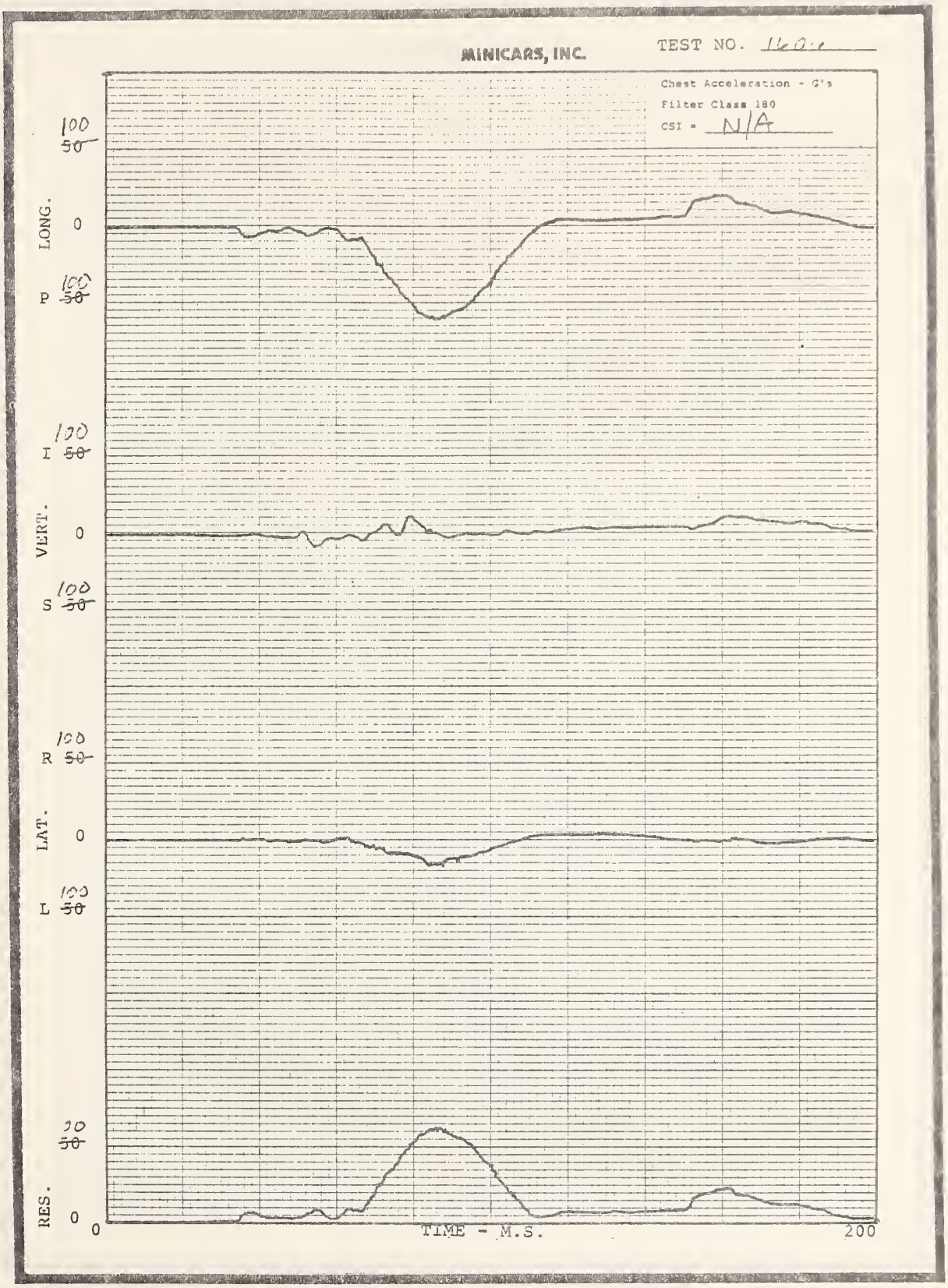

MINICARS, INC.
TEST NO. 1591
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
.000
0
2000
2000
0
2000
+ 10
0
- 10
25
0
25
TIME - M.S.
0
200

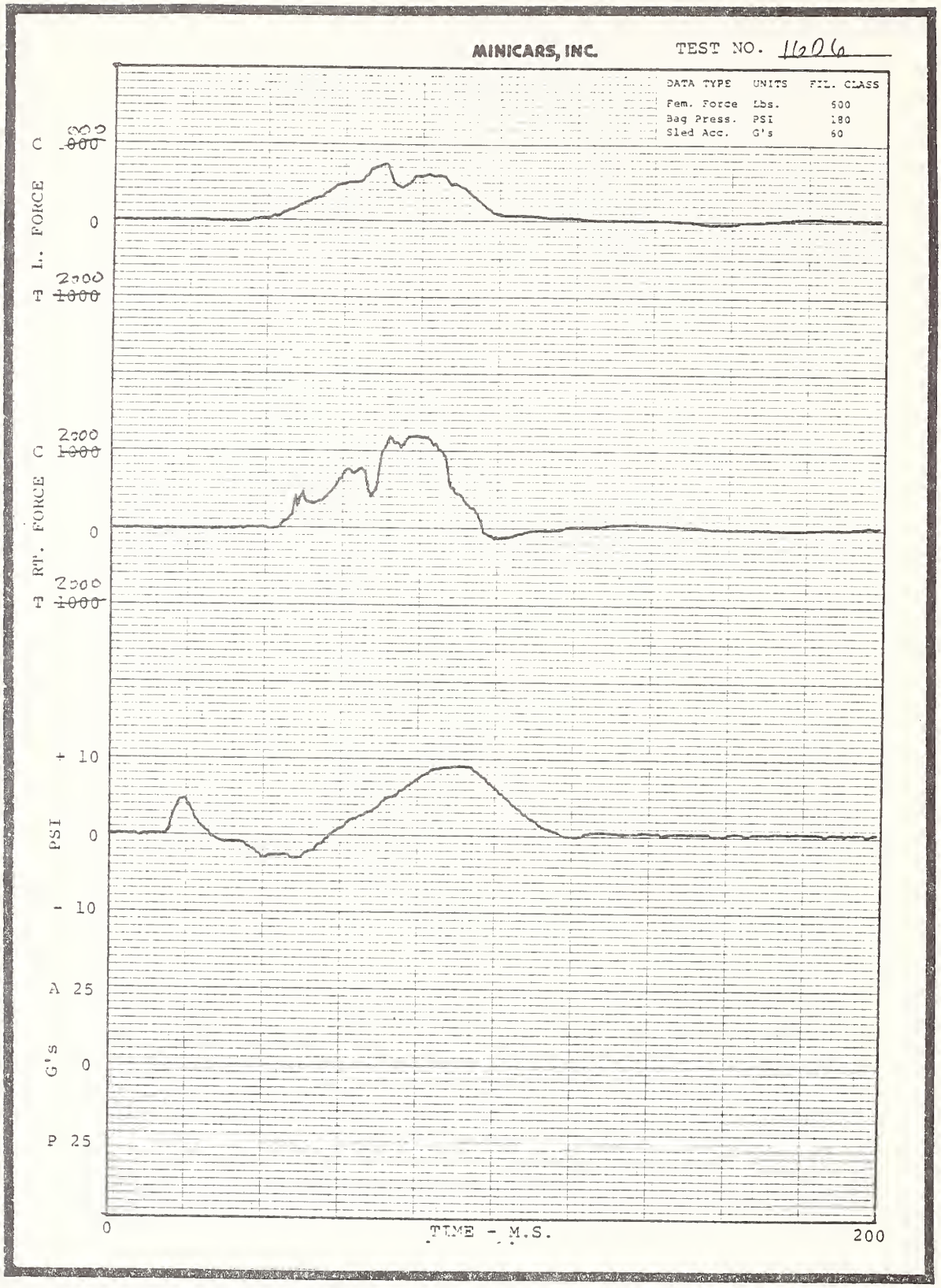

MINICARS, INC.
1591
AIR BAG PRESSURES
DVR.
PASS
F.C. 180
10
PSI
0
10
PSI
0
0
TIME - M.S
200

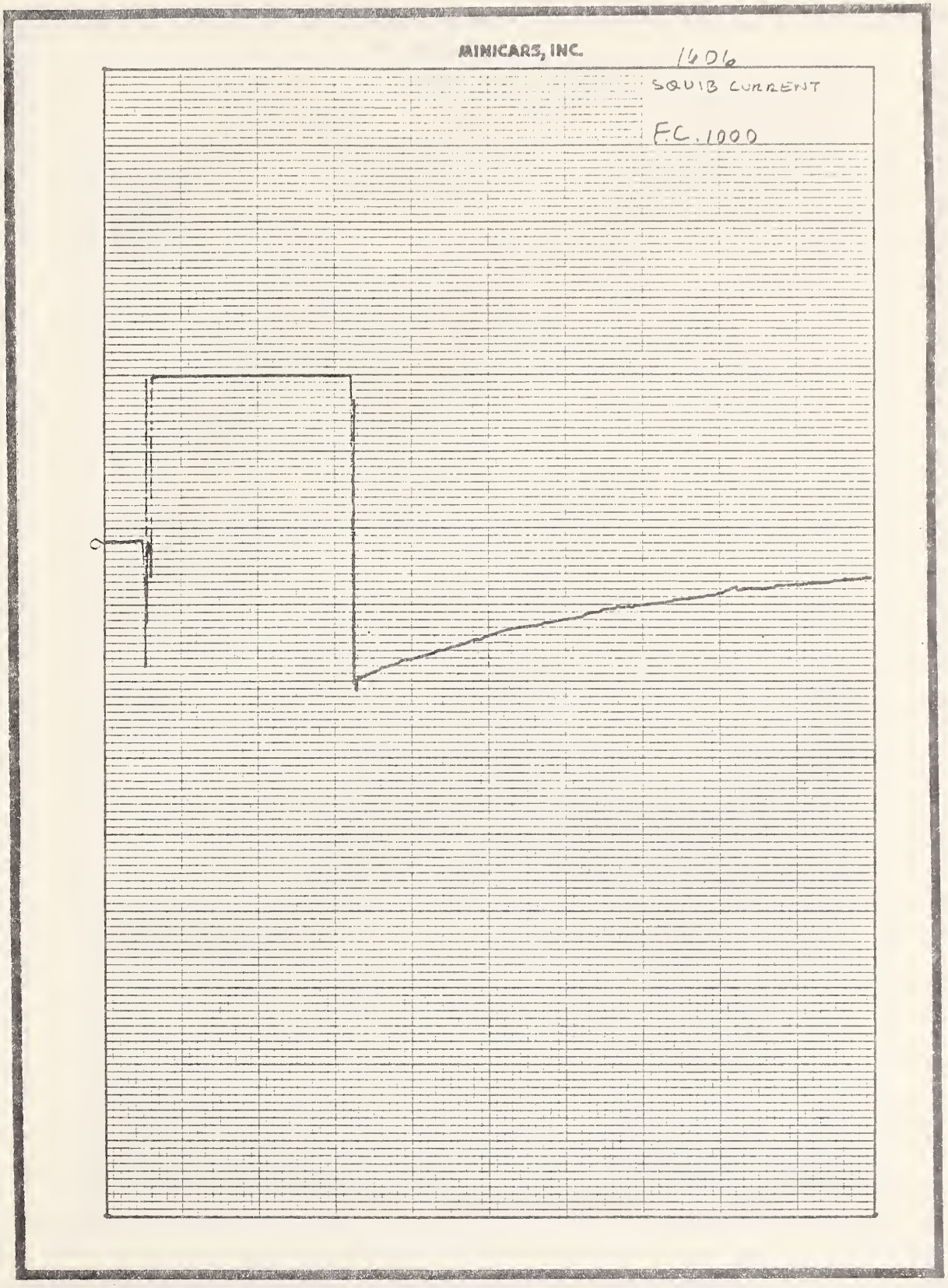

MINICARS, INC.
1591
SQUIB CURRENT
(UNCALIBRATED)
0
TIME - M.S
200

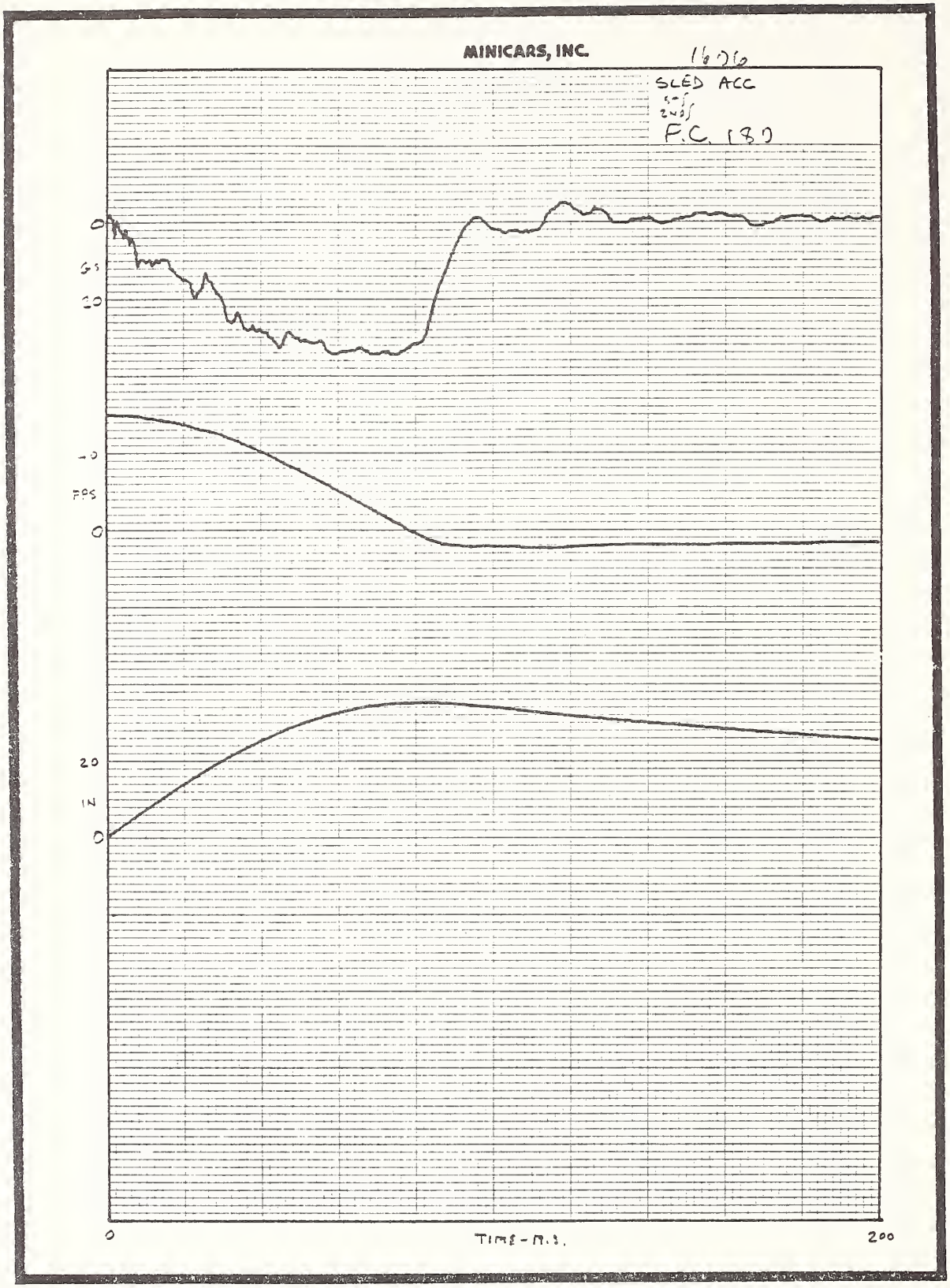

MINICARS, INC.
.591
SLED ACC
1ST ∫
2ND ∫
F.C.: 80
0
G's
20
40
FPS
0
20
IN
0
0
TIME - M.S.
200

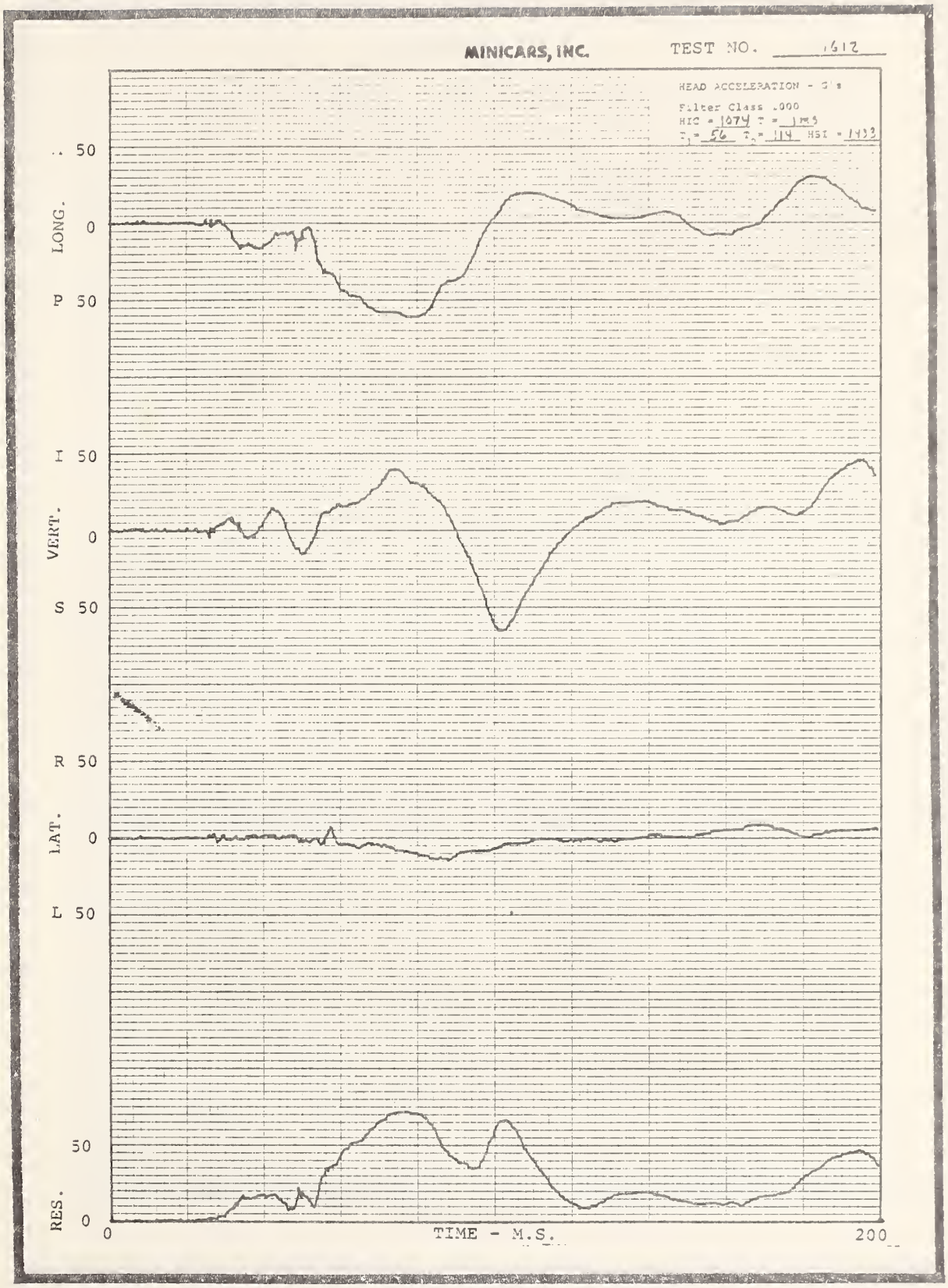

MINICARS, INC.
TEST NO. 16016
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 1822 T = 1MS
T1 = .01 T2 = .01 HSI = N/A
50
LONG.
0
50
50
VERT.
0
50
50
LAT.
0
50
50
RES.
0
0
TIME - M.S.
200

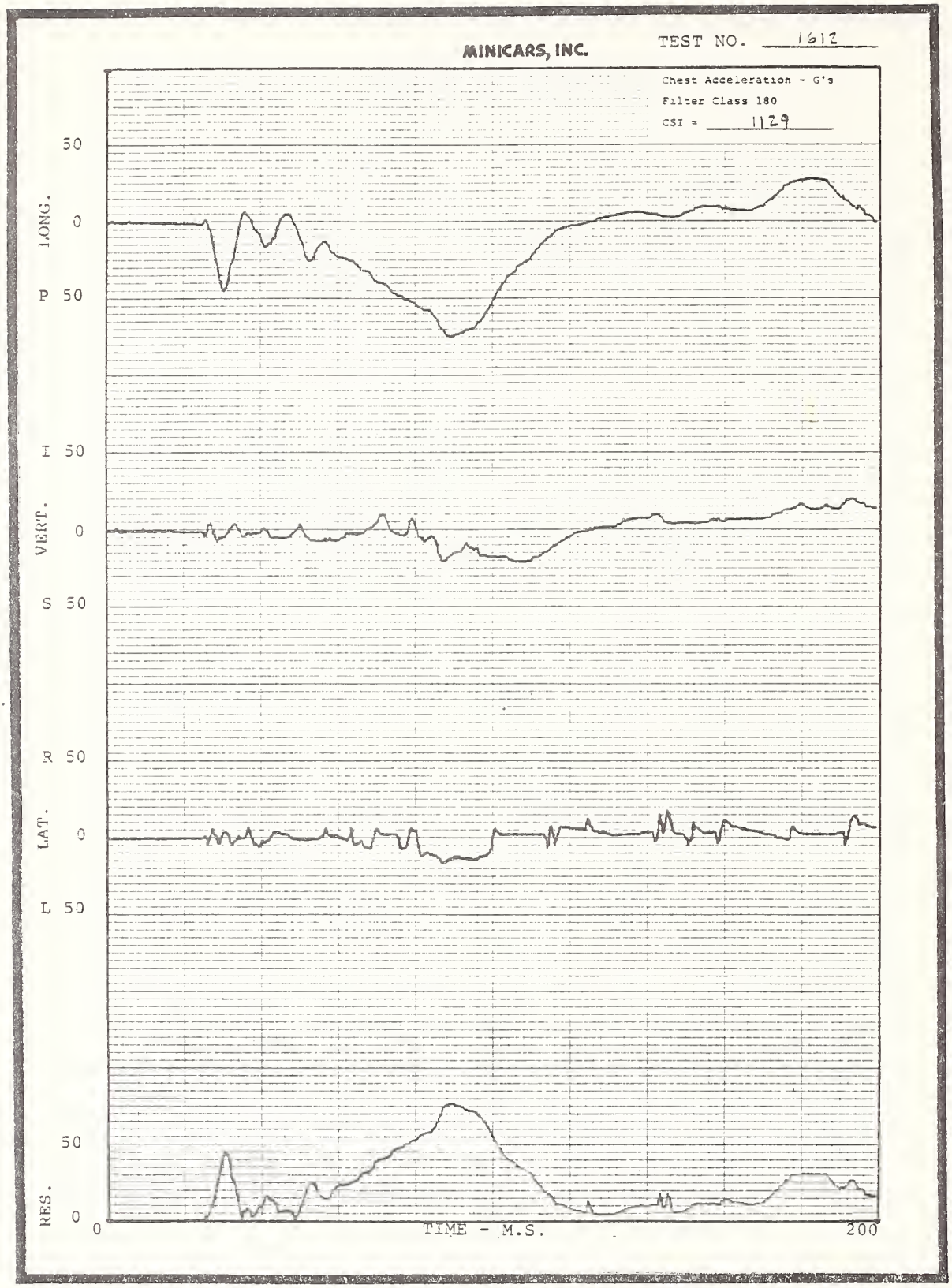

MINICARS, INC.
TEST NO. 160-e
Chest Acceleration - G's
Filter Class 180
CSI = N/A
LONG.
P
VERT.
I
S
LAT.
R
L
RES.
100
50
0
TIME - M.S.
200

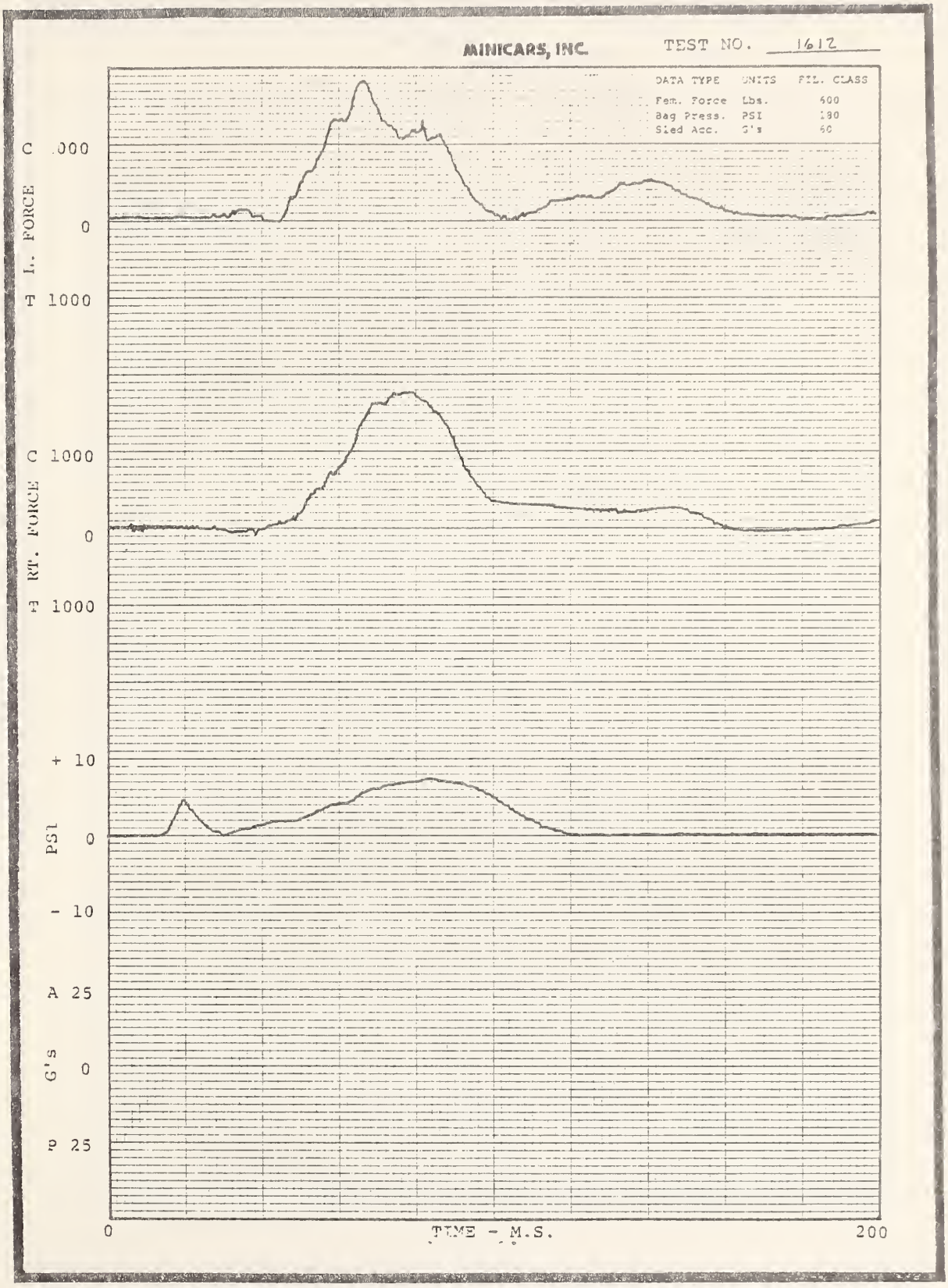

MINICARS, INC.
TEST NO. 11206
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 600 ~~800~~
0
T L. FORCE
2000 ~~1000~~
2000 ~~1000~~
C
0
T RT. FORCE
2000 ~~1000~~
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

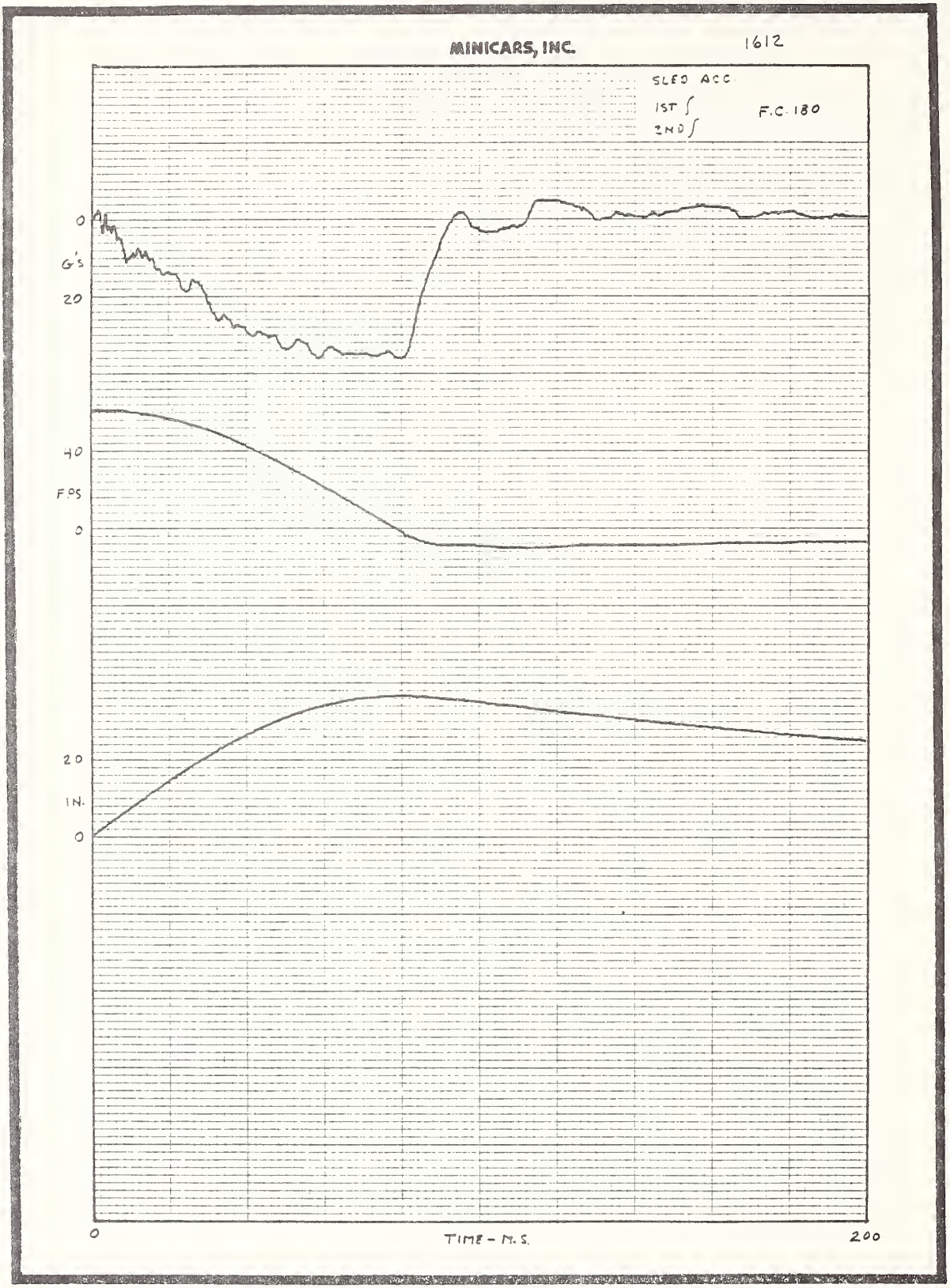

MINICARS, INC.
1606
SQUIB CURRENT
F.C. 1000

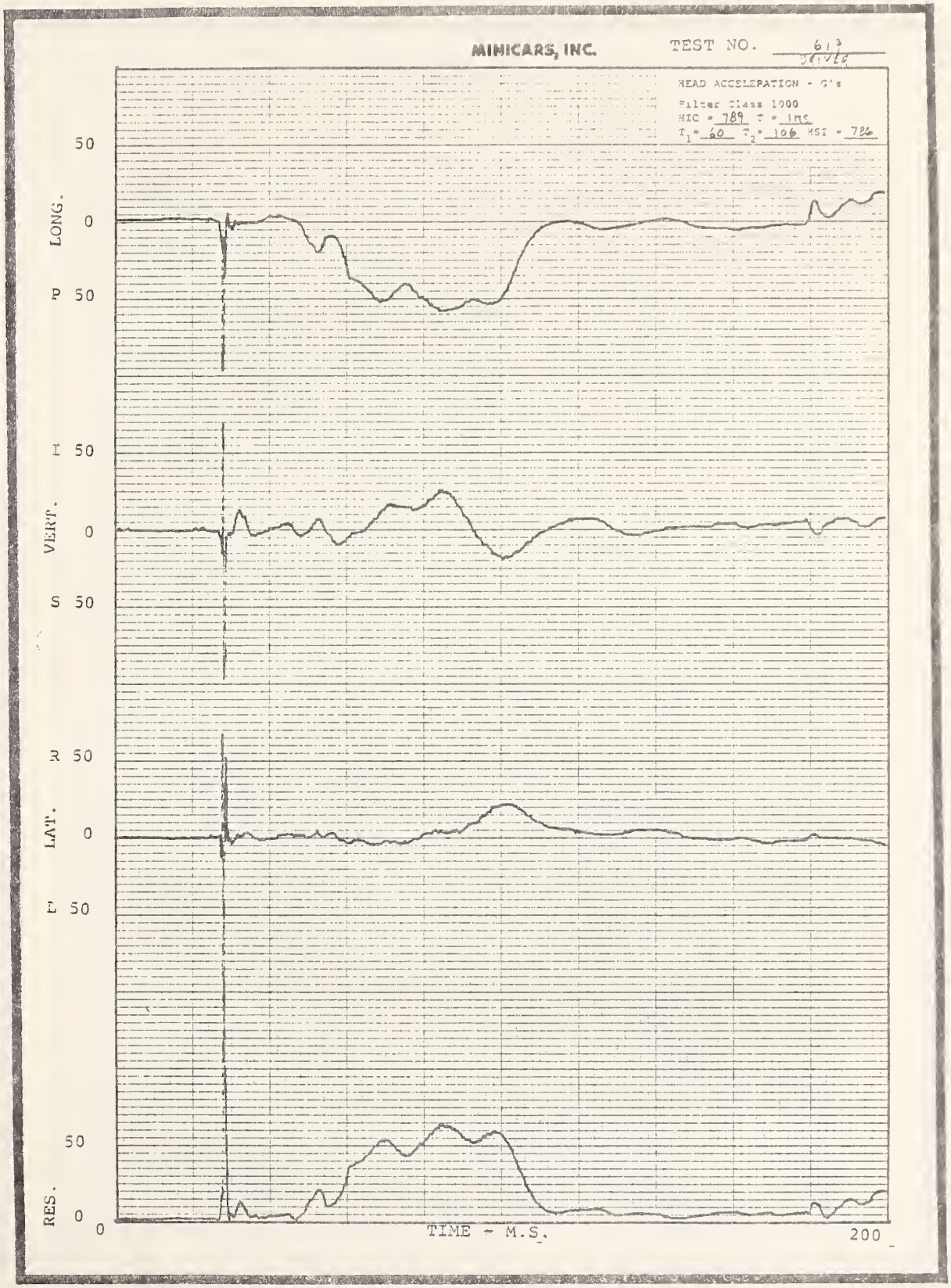

MINICARS, INC.
SLED ACC
F.C. 130
0
20
IN
0
200

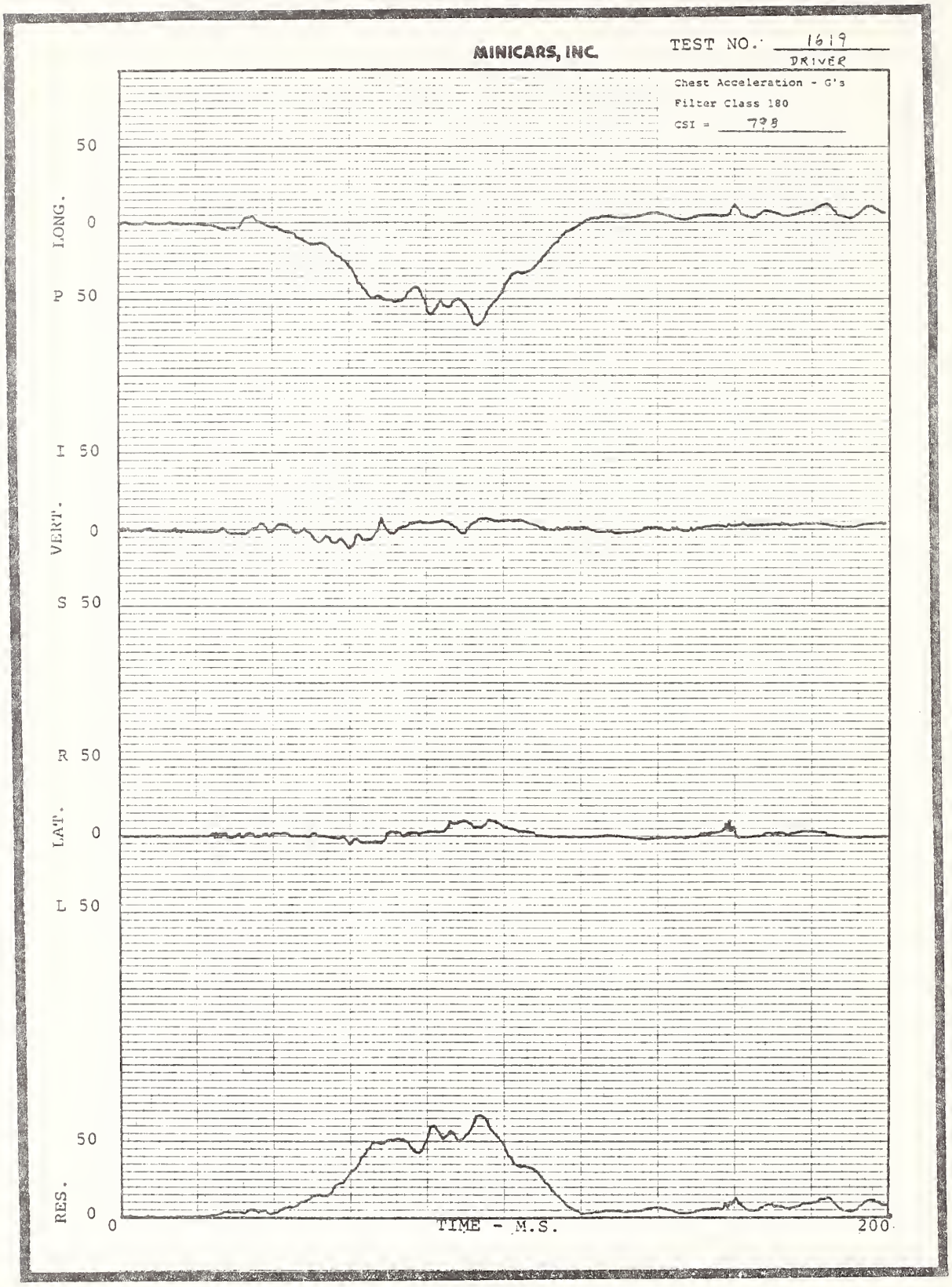

MINICARS, INC.
TEST NO. 1612
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 1074
HSI = 1433
LONG.
P 50
0
VERT.
I 50
S 50
LAT.
R 50
L 50
RES.
50
0
0
TIME - M.S.
200

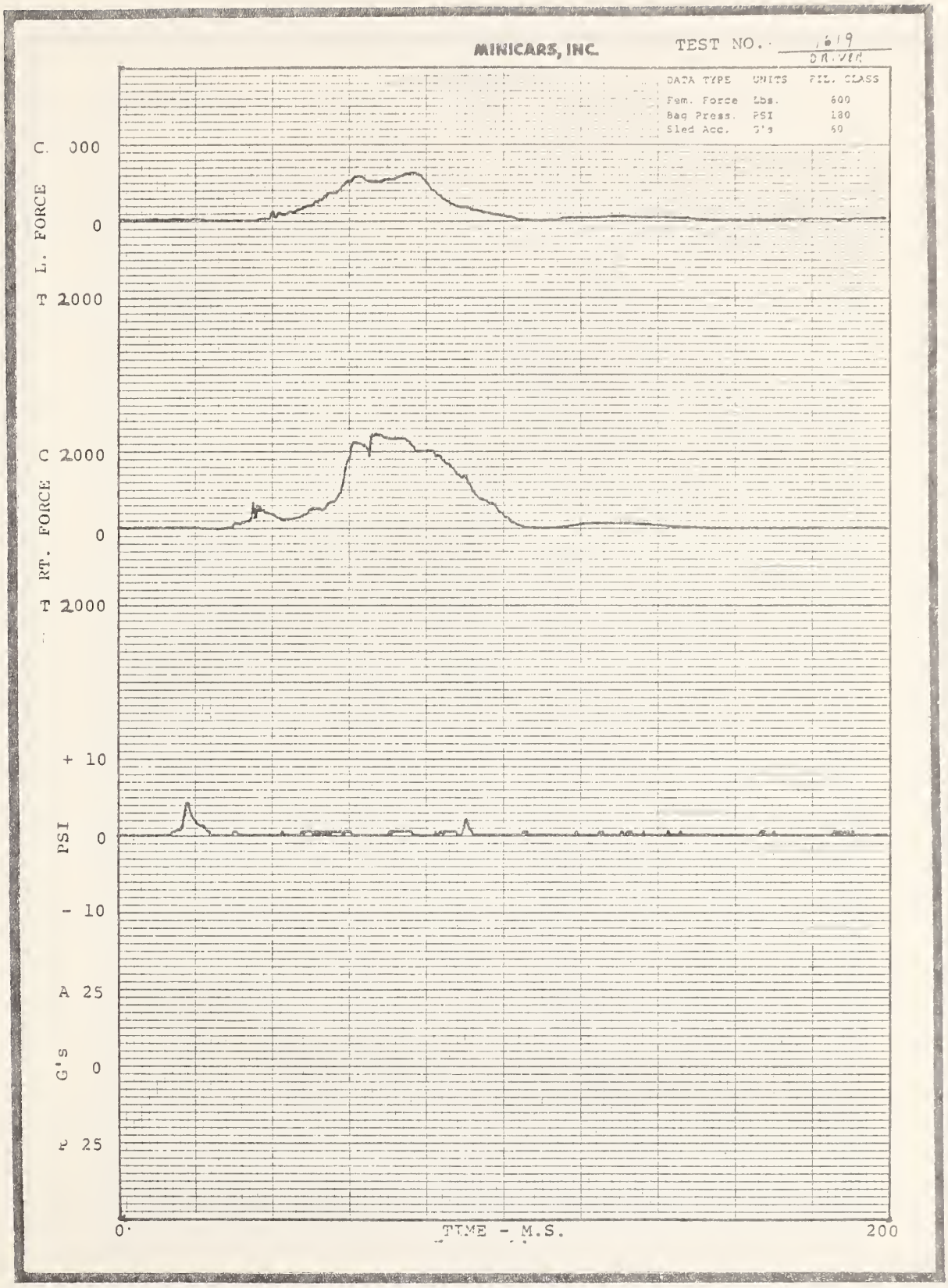

MINICARS, INC.
TEST NO. 1612
Chest Acceleration - G's
Filter Class 180
CSI = 1129
LONG.
P 50
0
VERT.
I 50
0
S 50
LAT.
R 50
0
L 50
RES.
50
0
0
TIME - M.S.
200

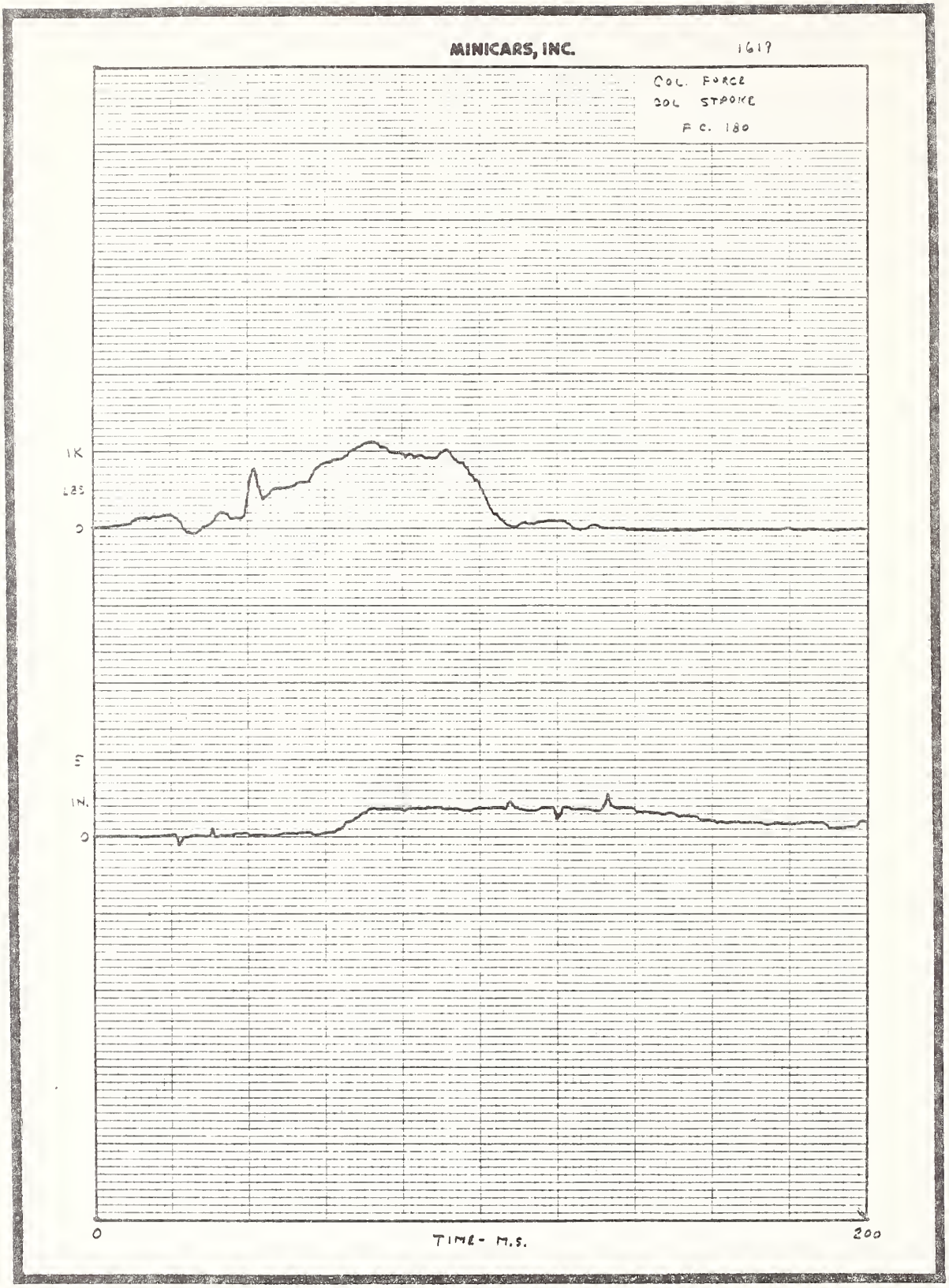

MINICARS, INC.
TEST NO. 1612
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C .000
0
T 1000
C 1000
0
T 1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

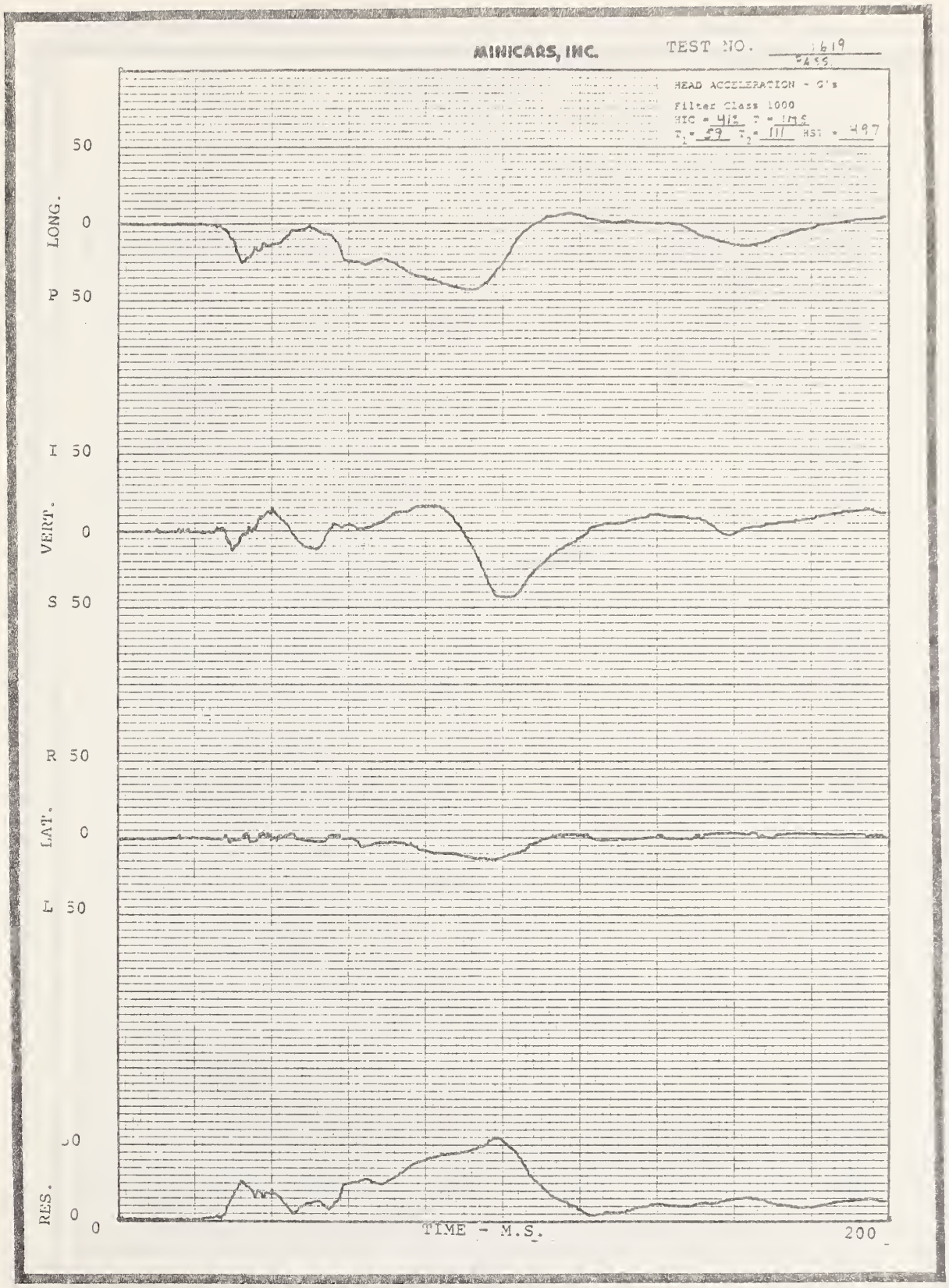

MINICARS, INC.
1612
SLED ACC.
1ST ∫
2ND ∫
F.C. 180
0
G'S
20
40
F.P.S
0
20
IN.
0
0
TIME - M.S.
200

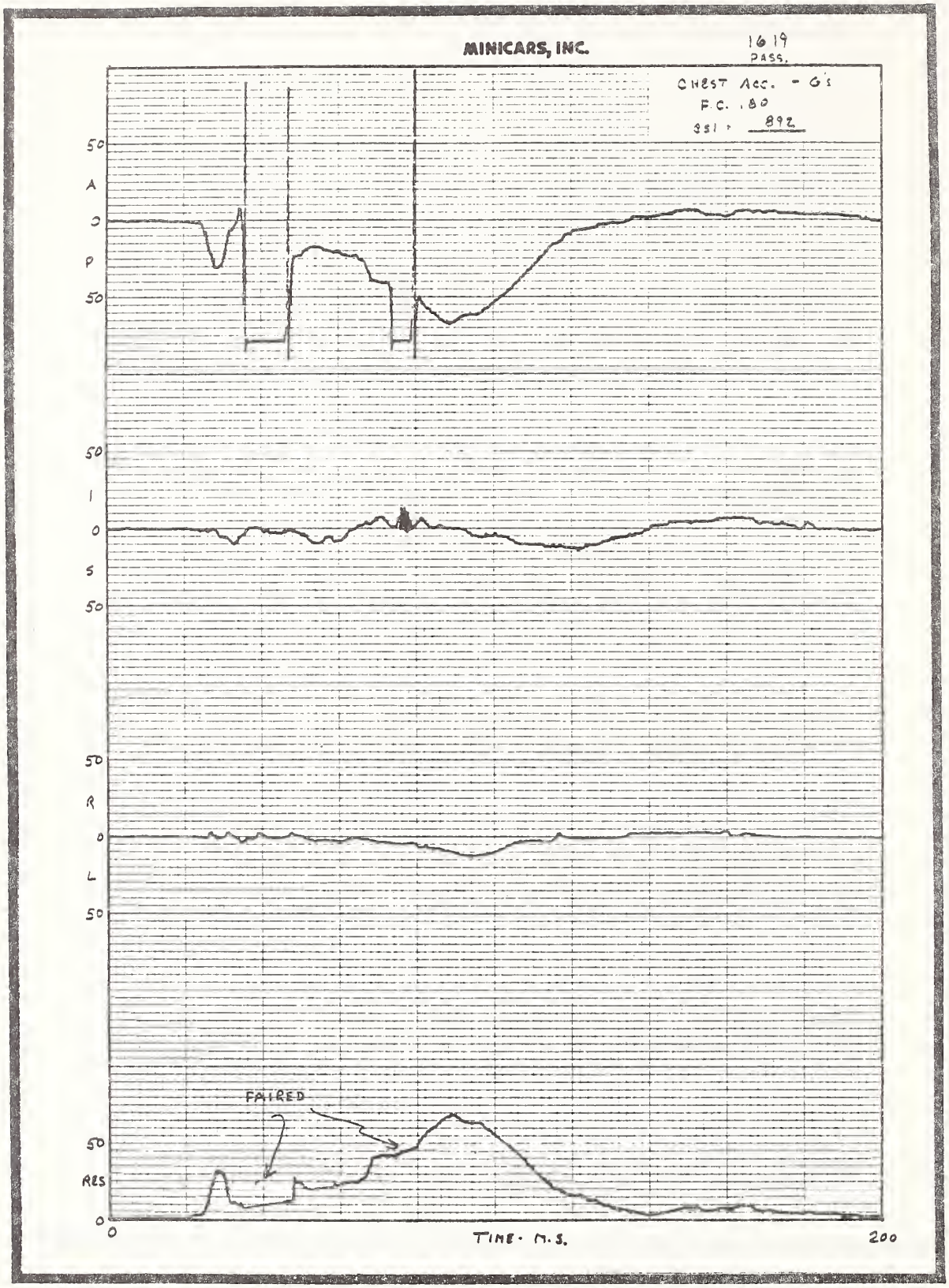

MINICARS, INC.
TEST NO. 613
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 789 T = 1ms
T1 = 60 T2 = 106 HSI = 786
LONG.
VERT.
LAT.
RES.
50
0
TIME - M.S.
200

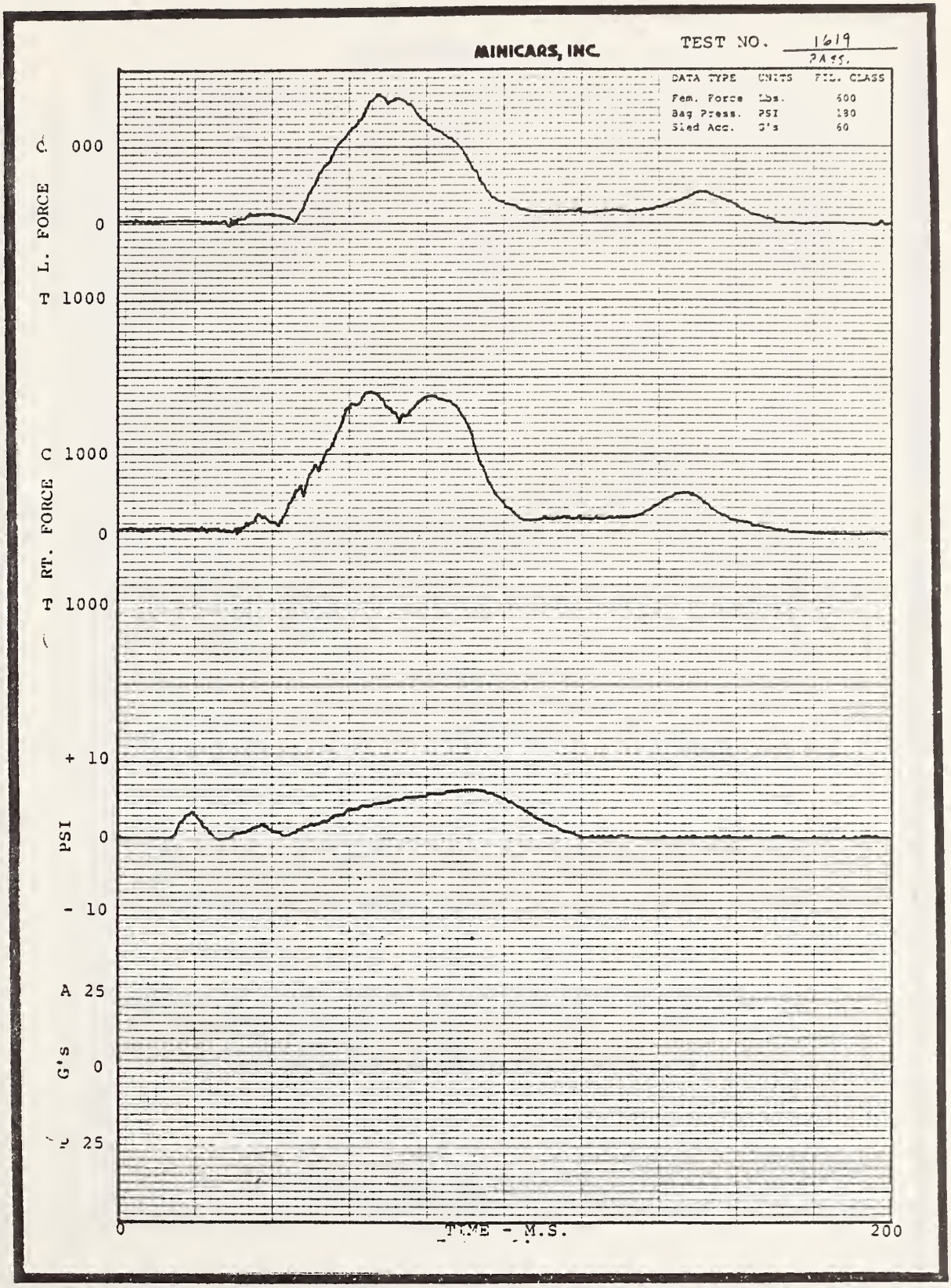

MINICARS, INC.
TEST NO. 1619
DRIVER
Chest Acceleration - G's
Filter Class 180
CSI = 728
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

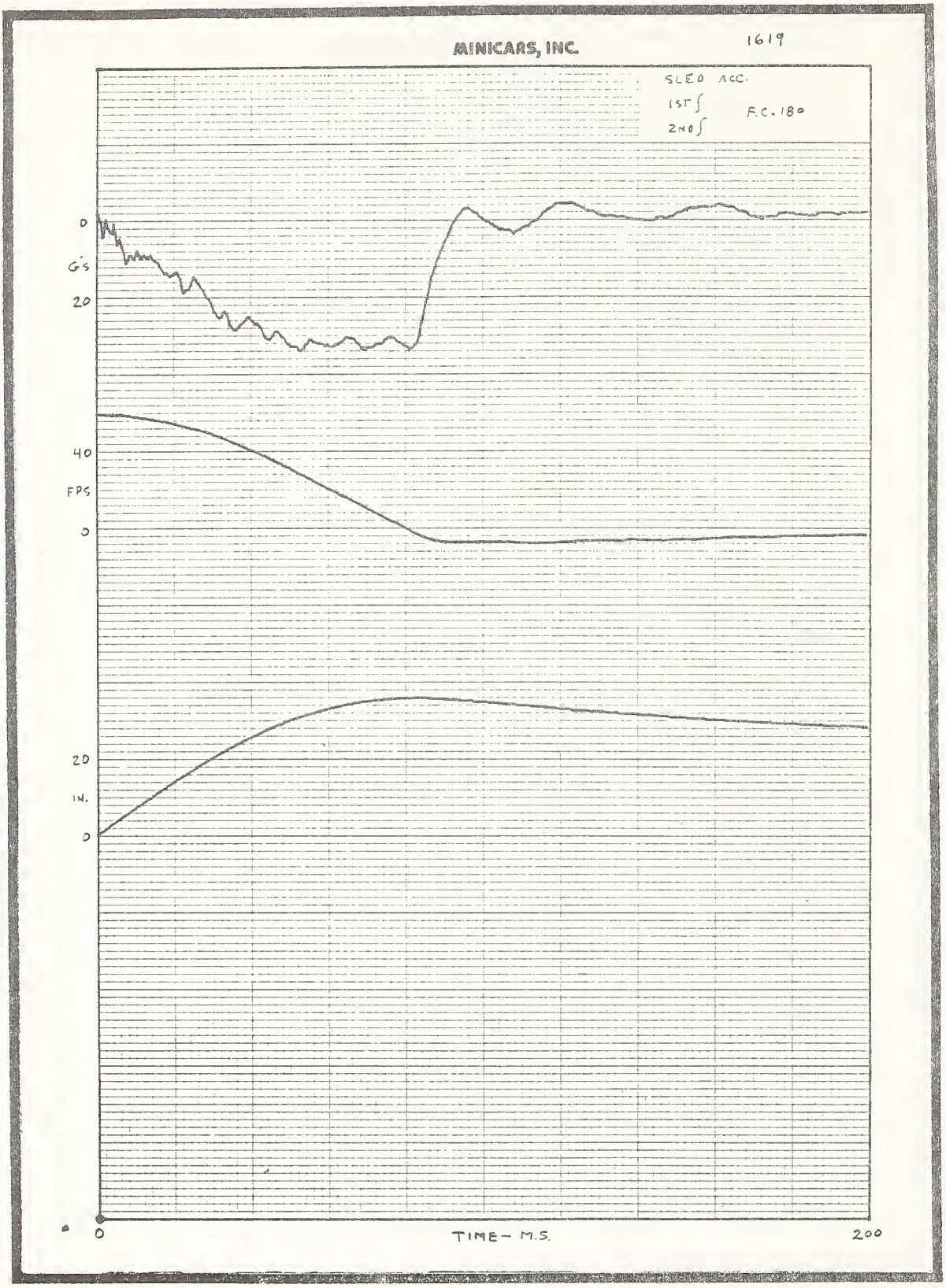

MINICARS, INC.
TEST NO. 1619
DRIVER
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 000
0
T 2000
L. FORCE
C 2000
0
T 2000
RT. FORCE
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

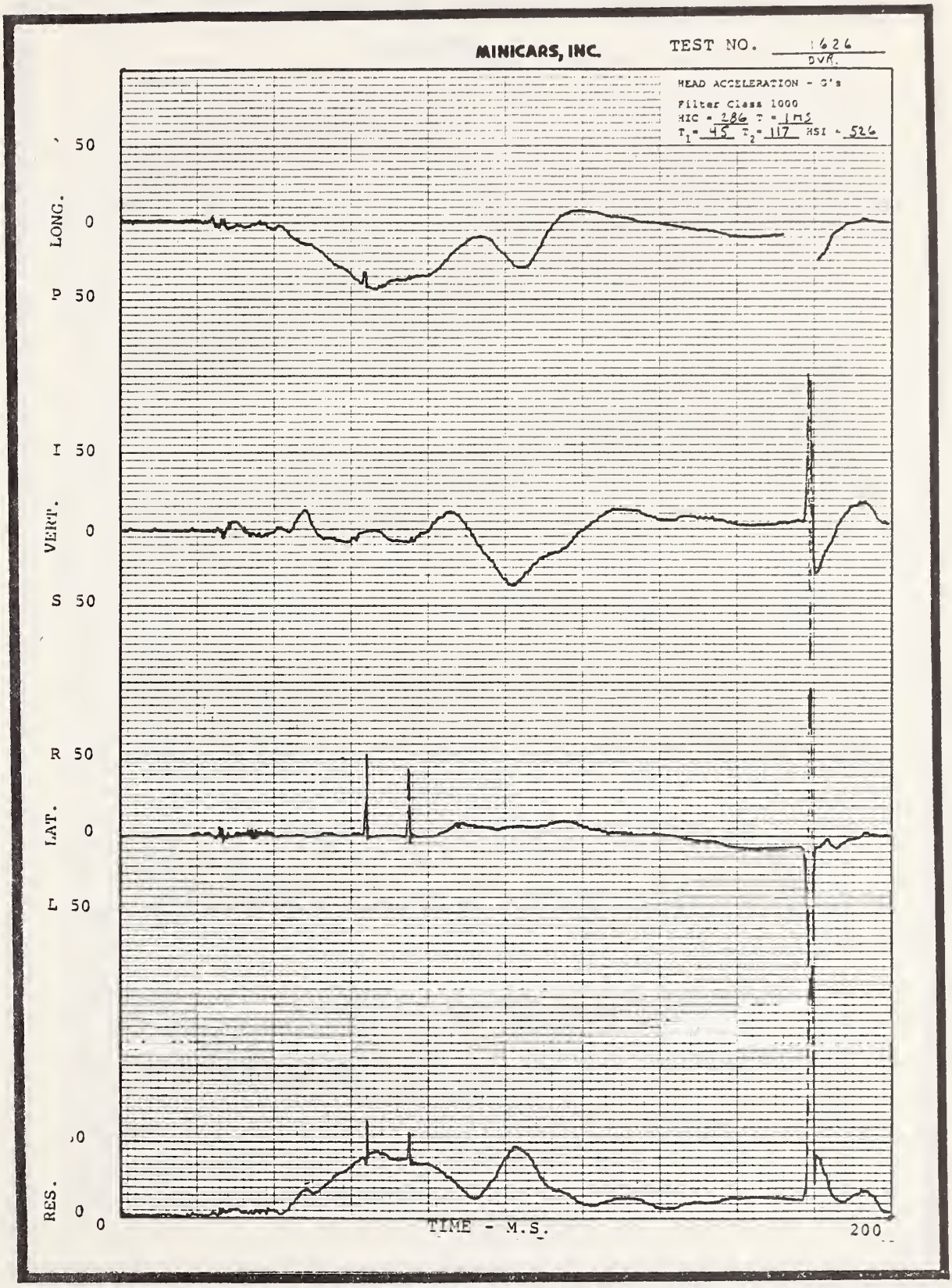

MINICARS, INC.
1619
COL. FORCE
COL STROKE
F.C. 180
1K
.25
0
IN.
0
0
TIME- M.S.
200

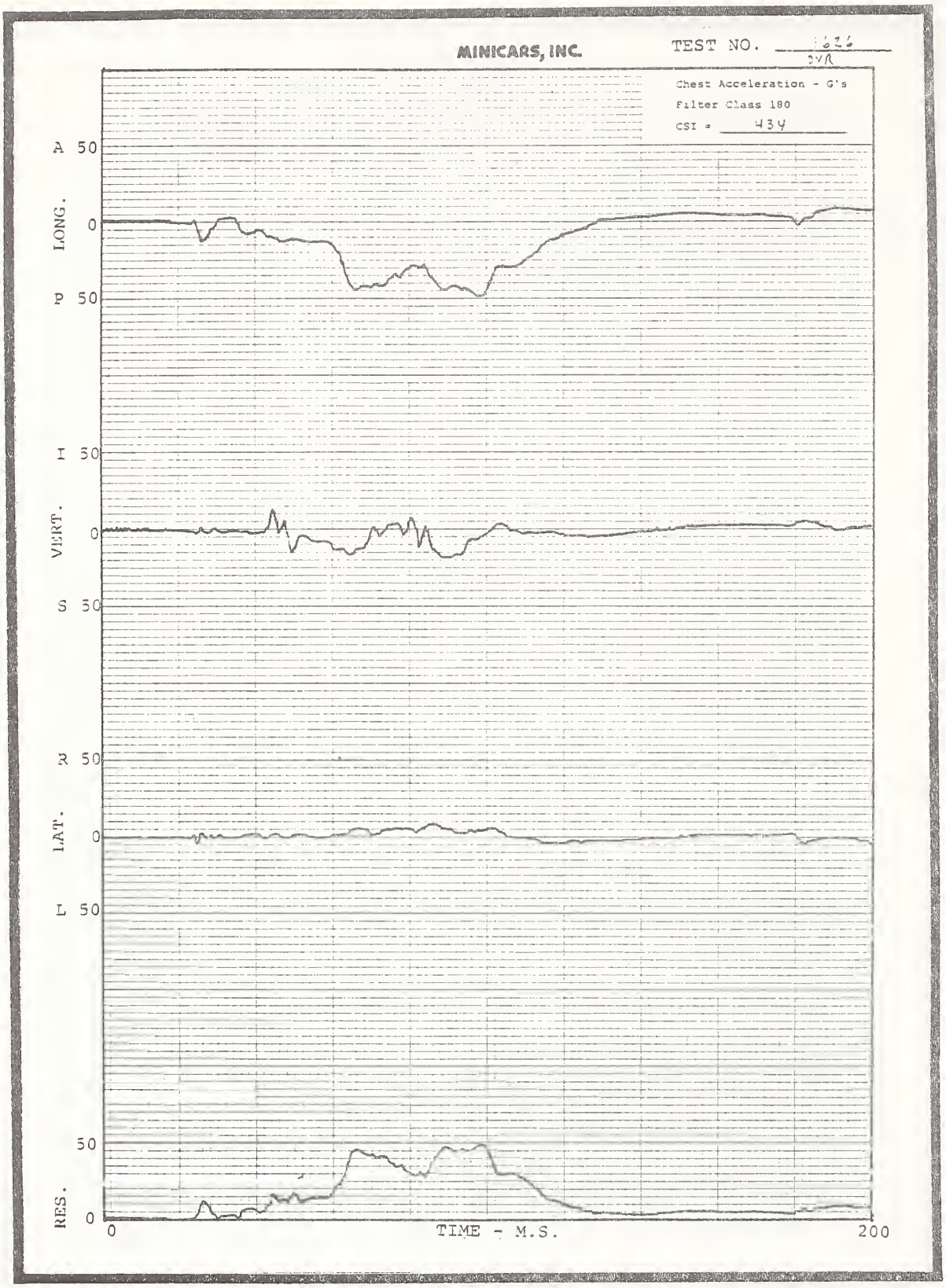

MINICARS, INC.
TEST NO. 1619
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 412 T = 145
T1 = 59 T2 = 111 HST = 497
LONG.
P 50
0
VERT.
I 50
0
S 50
LAT.
R 50
0
L 50
RES.
0
TIME - M.S.
200

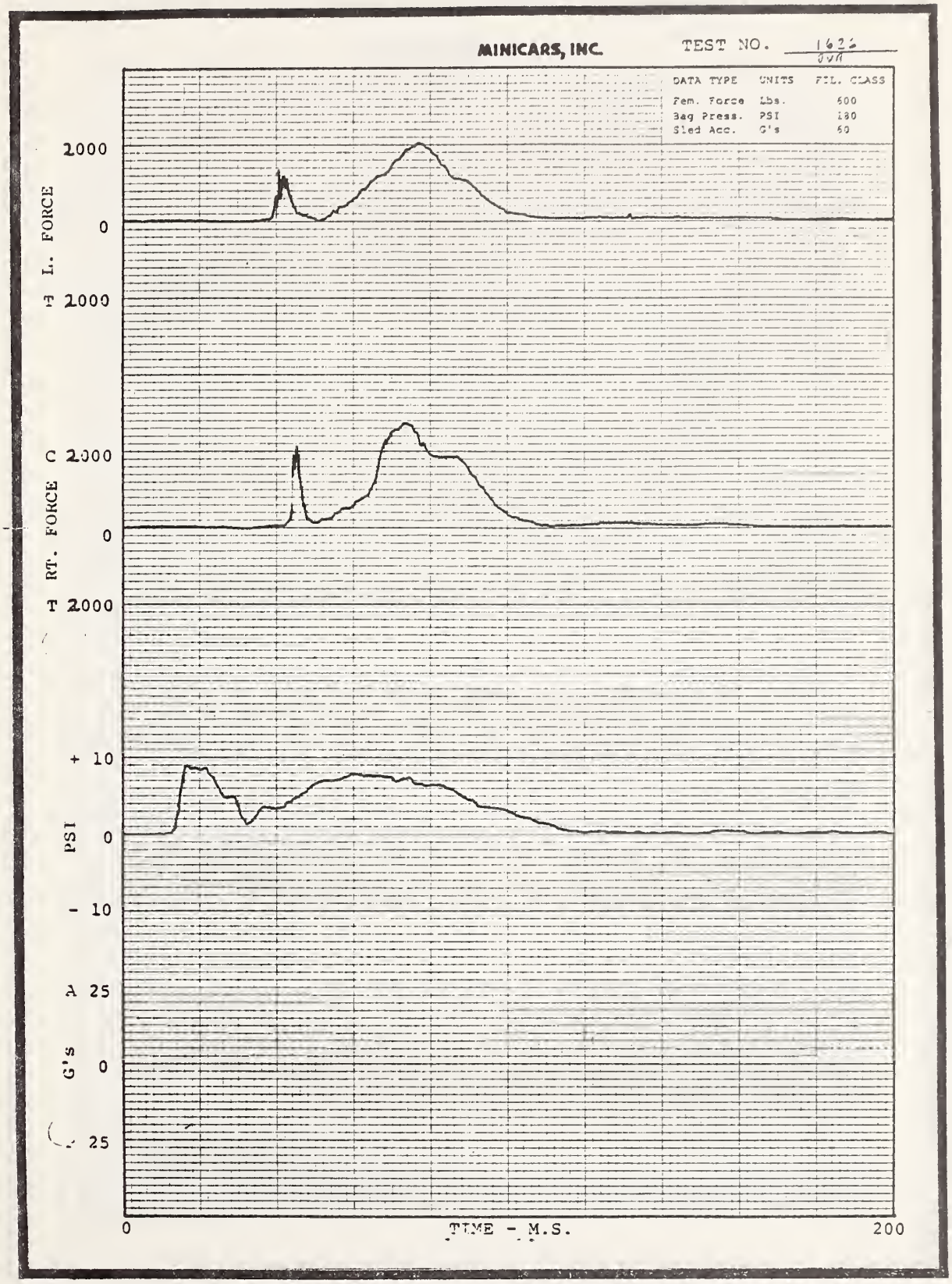

MINICARS, INC.
1619
PASS.
CHEST ACC. - G's
F.C. .80
SSI # 892
50
A
O
P
50
50
I
O
S
50
50
R
O
L
50
FAIRED
50
RES
O
O
TIME - M.S.
200

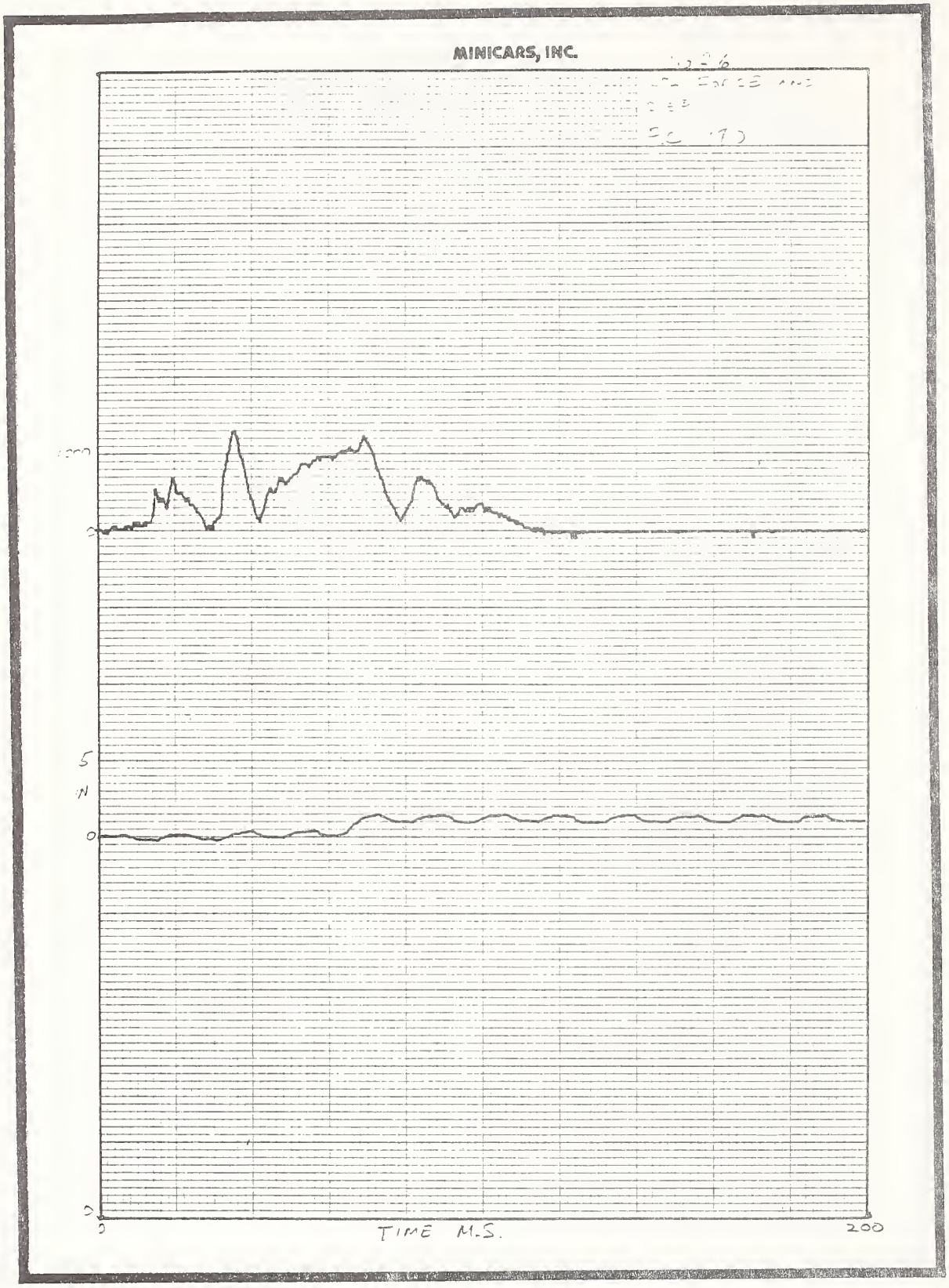

MINICARS, INC.
TEST NO. 1619
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
000
0
1000
1000
0
1000
+ 10
0
- 10
25
0
25
0
TIME - M.S.
200

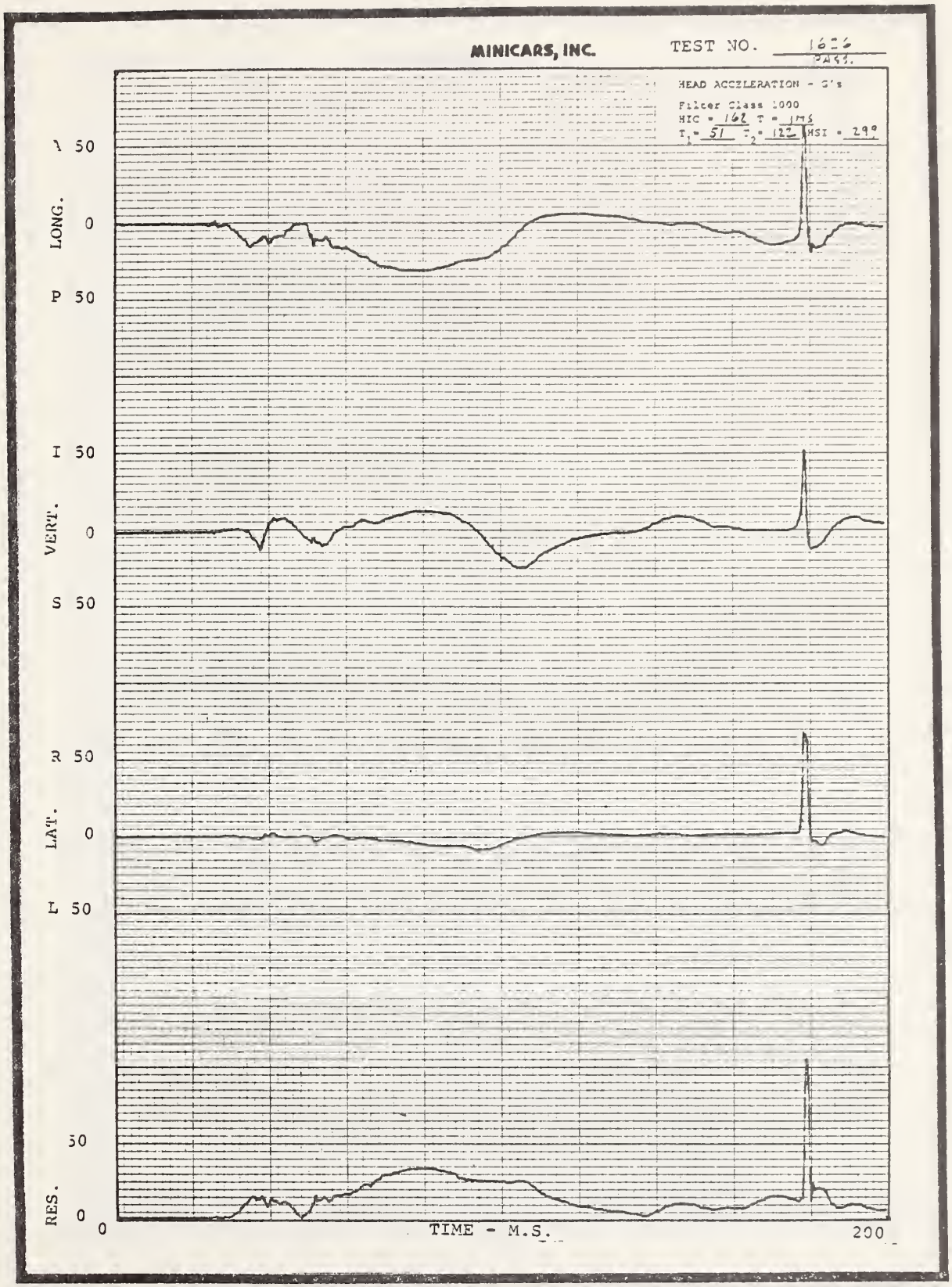

MINICARS, INC.
1619
SLED ACC.
1ST ∫
2ND ∫
F.C. 180
0
G'S
20
40
FPS
0
20
IN.
0
0
TIME - M.S.
200

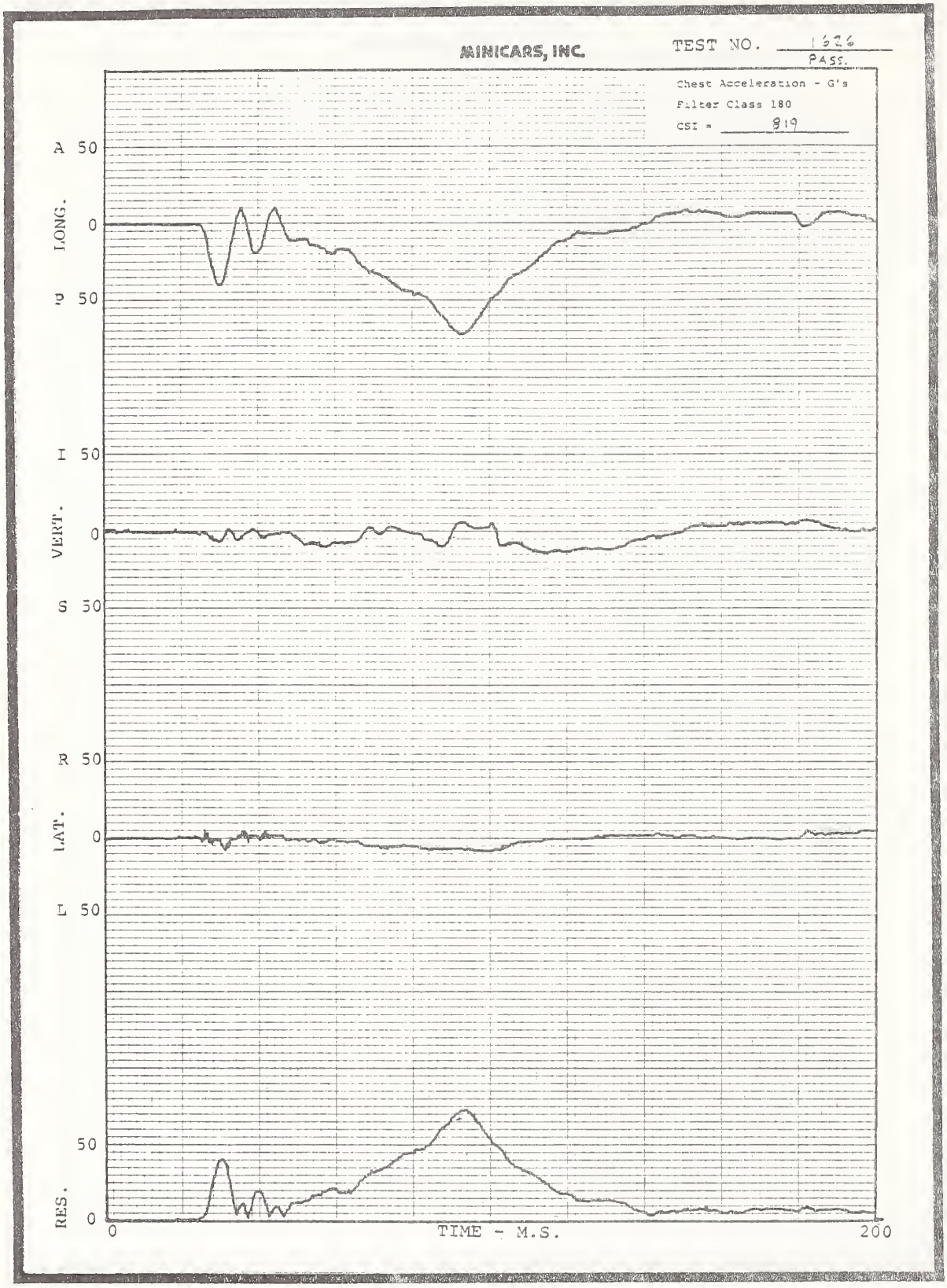

MINICARS, INC.
TEST NO. 1626
DVR.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 286 T = 1 MS
T1 = 45 T2 = 117 HSI = 526
LONG.
VERT.
LAT.
RES.
TIME - M.S.
200

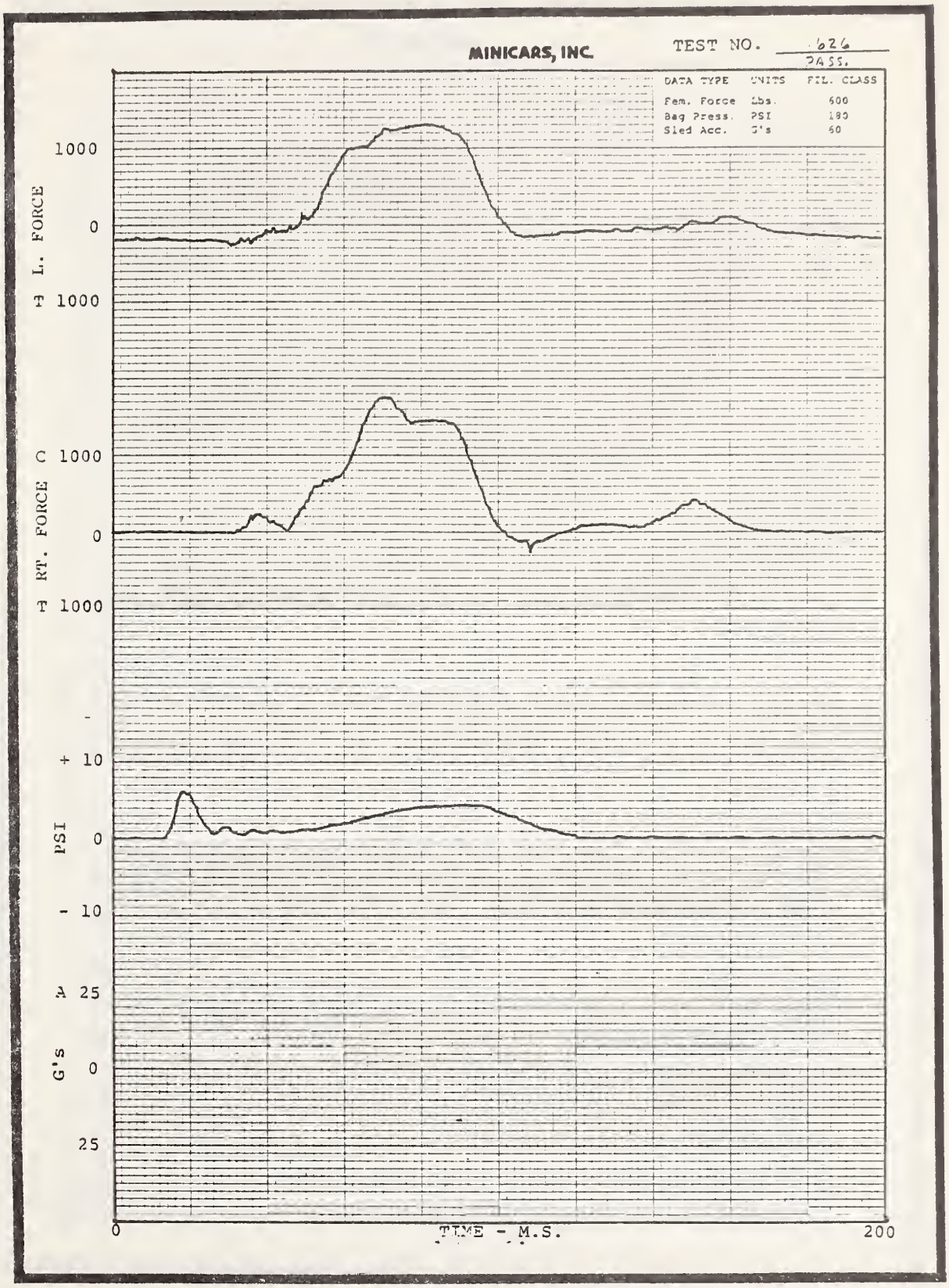

MINICARS, INC.
TEST NO.
Chest Acceleration - G's
Filter Class 180
CSI =
434
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

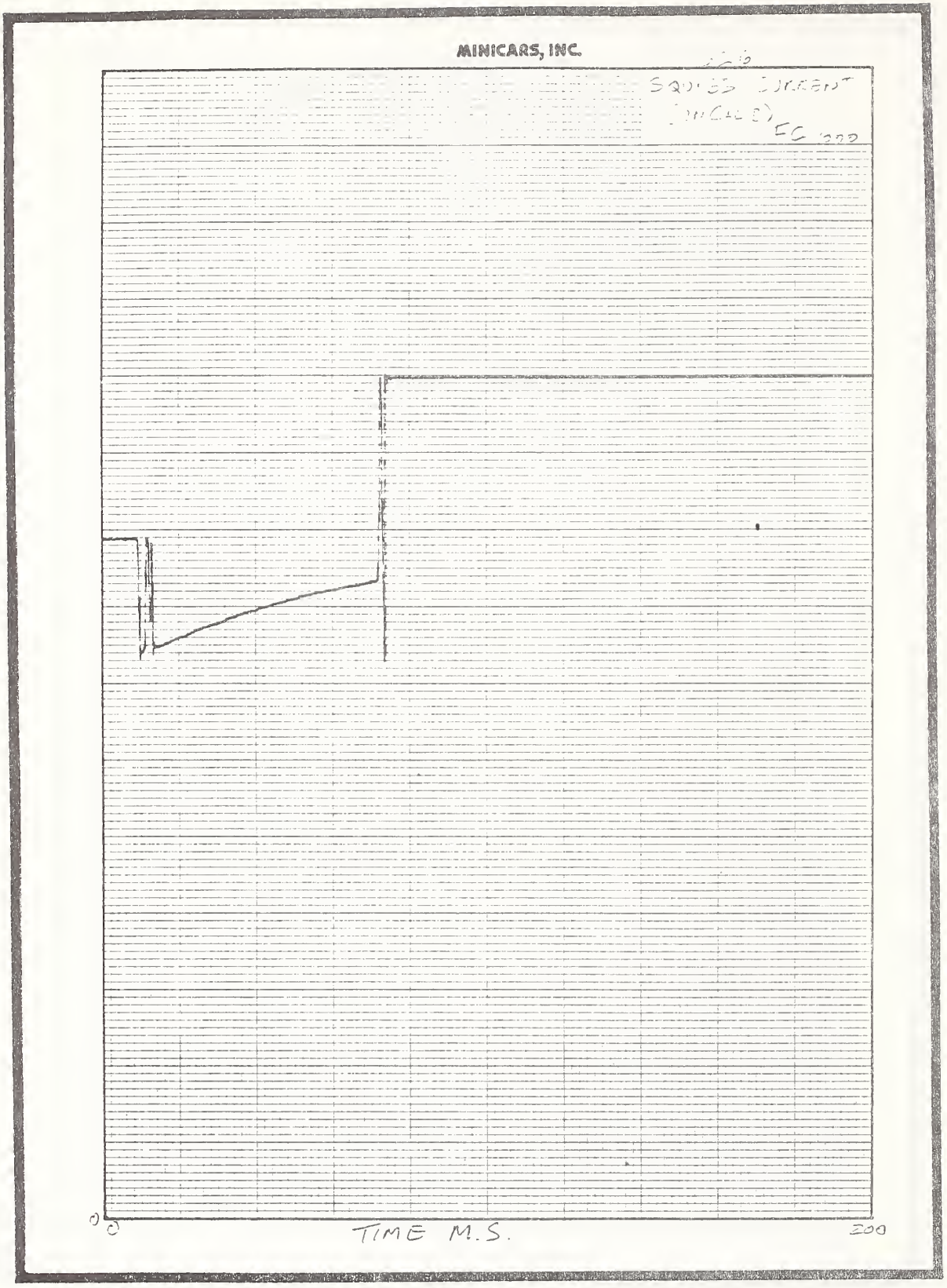

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
2000
0
2000
2000
0
2000
+ 10
0
- 10
25
0
25
0
200
TIME - M.S.

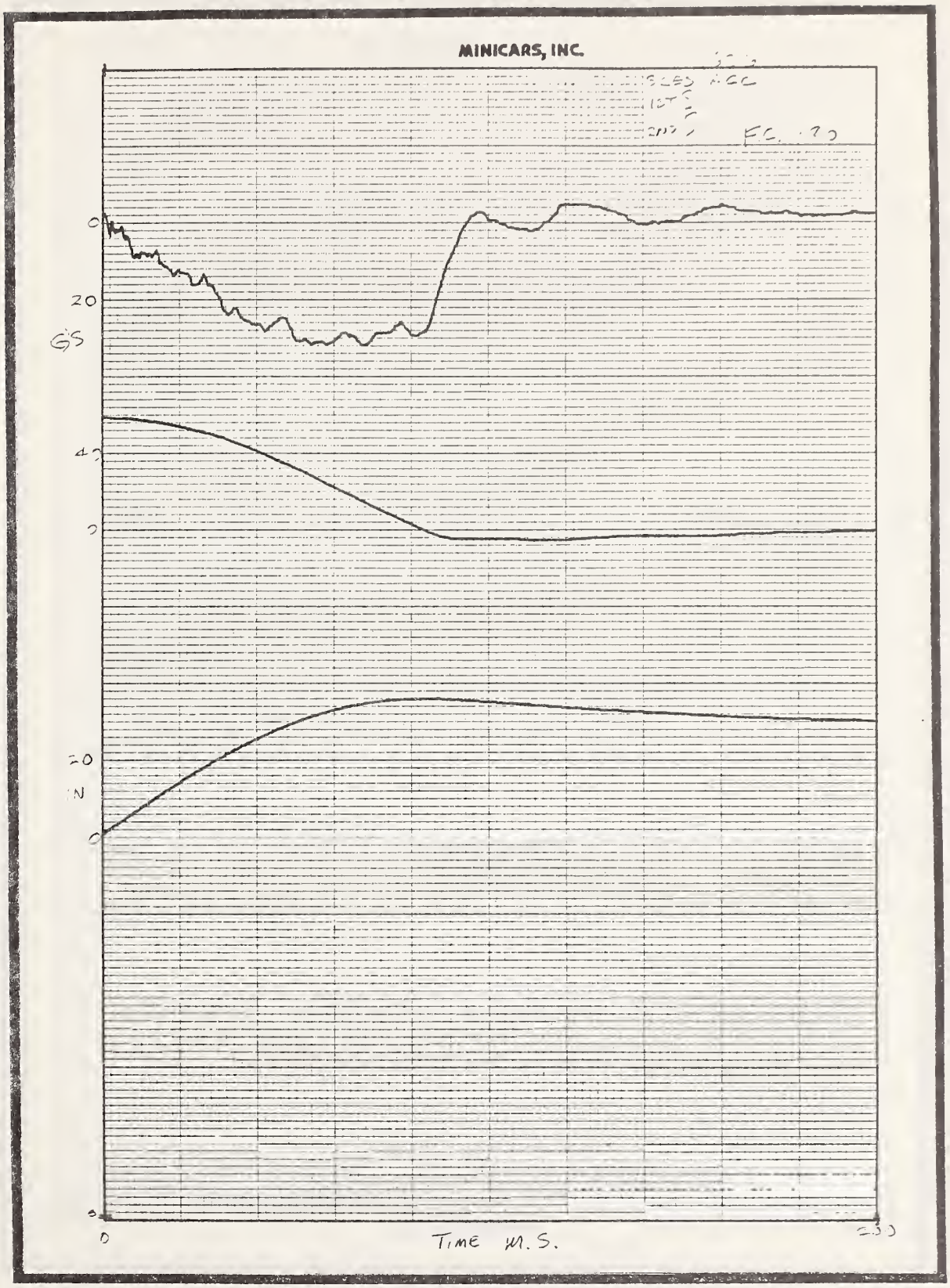

MINICARS, INC.
5
N
0
0
0
TIME M.S.
200

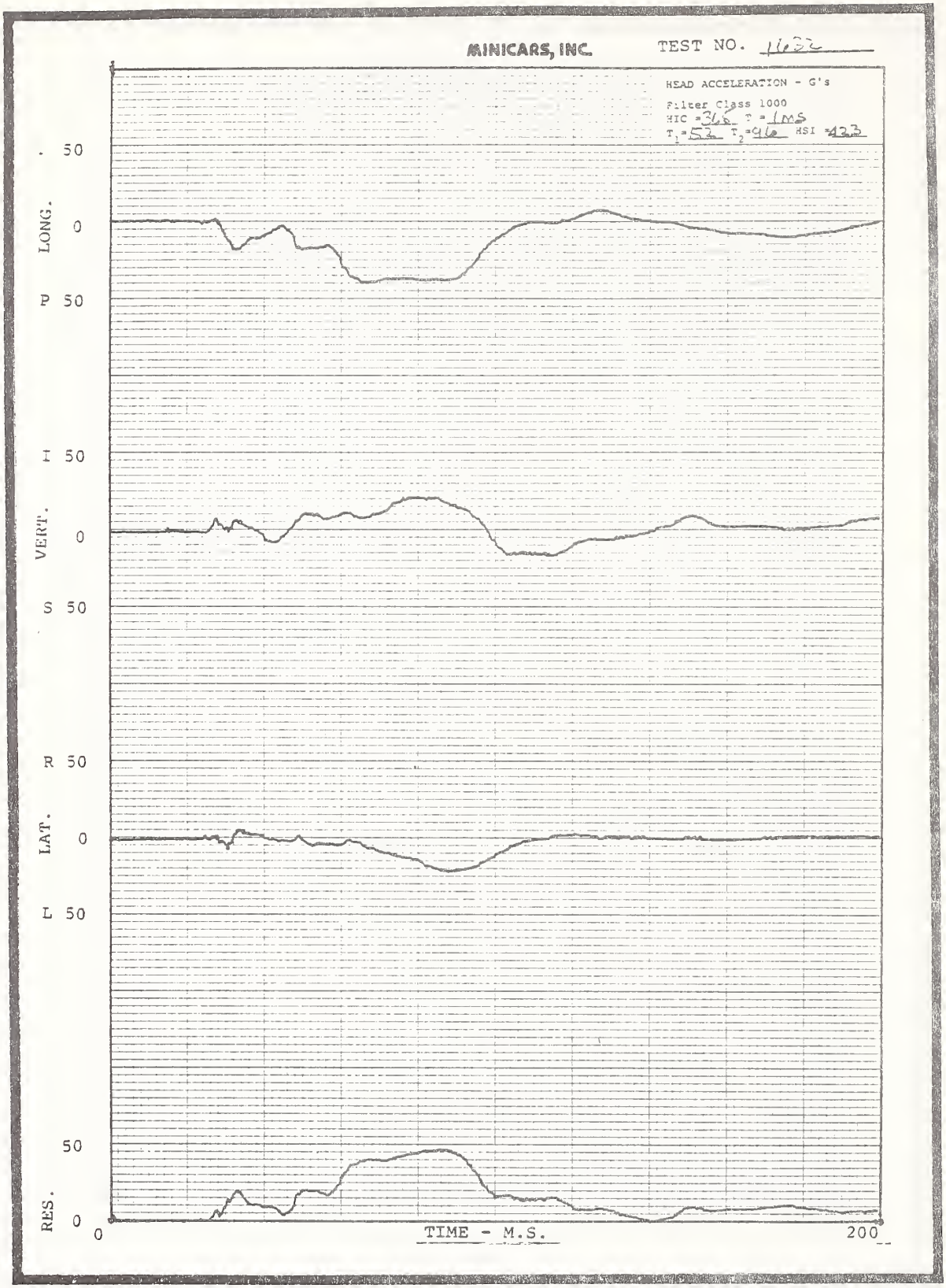

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 162 T = 1MS
T1 = 51 T2 = 122 HSI = 299
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

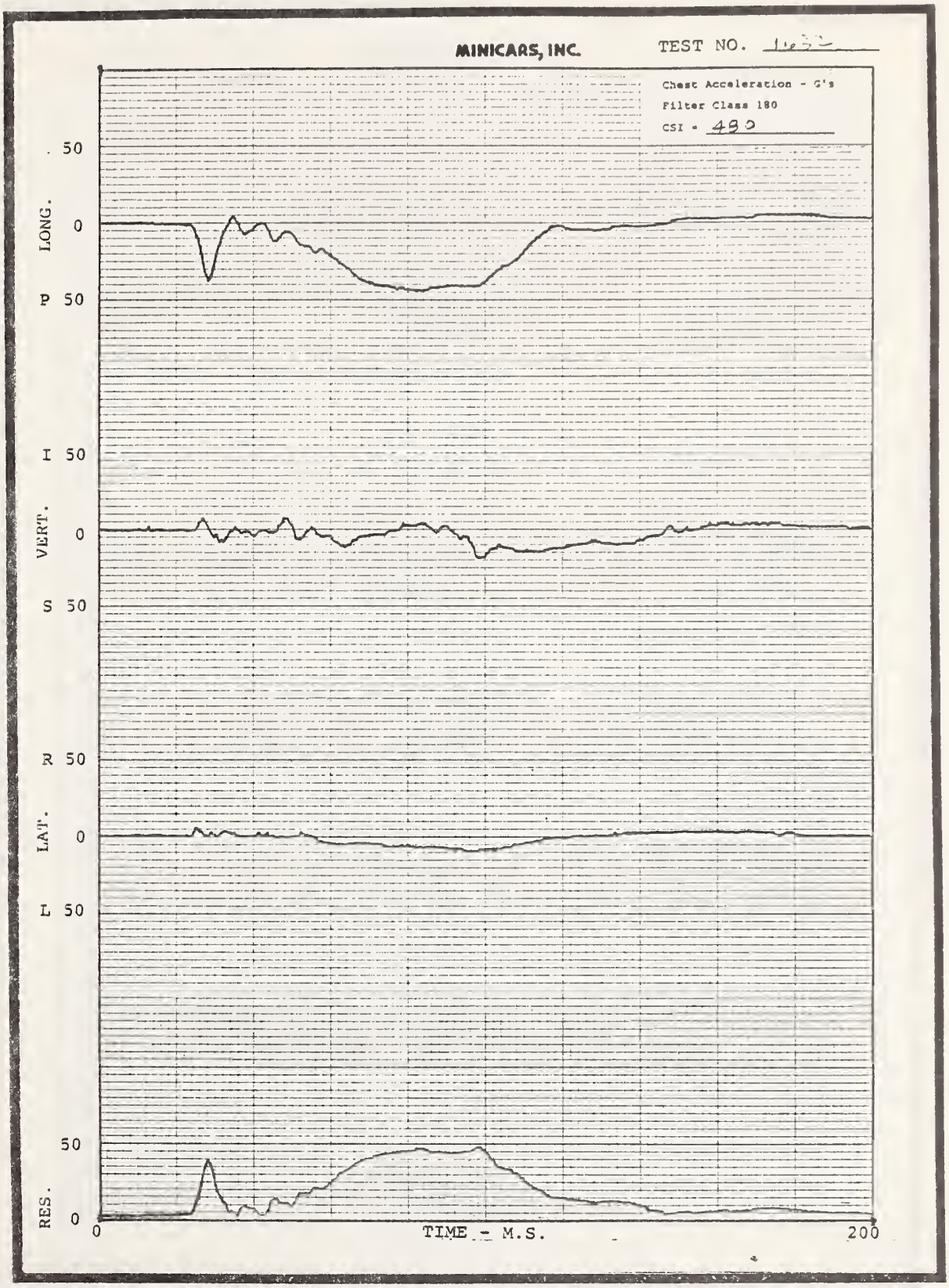

MINICARS, INC.
TEST NO. 1626
PASS.
Chest Acceleration - G's
Filter Class 180
CSI = 819
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

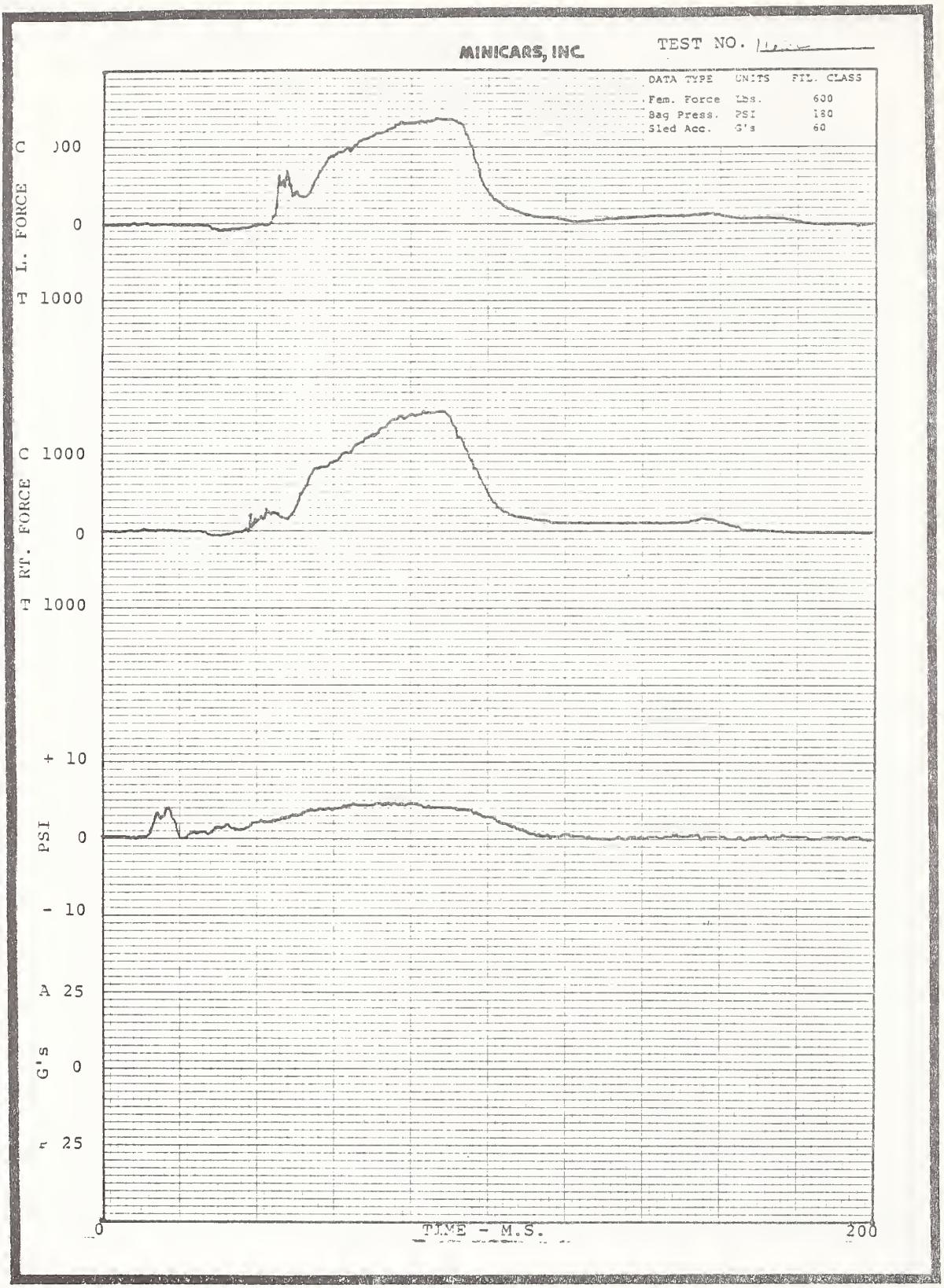

MINICARS, INC.
TEST NO. 626
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
1000
0
1000
L. FORCE
1000
0
1000
RT. FORCE
+ 10
0
- 10
PSI
25
0
25
G's
0
TIME - M.S.
200

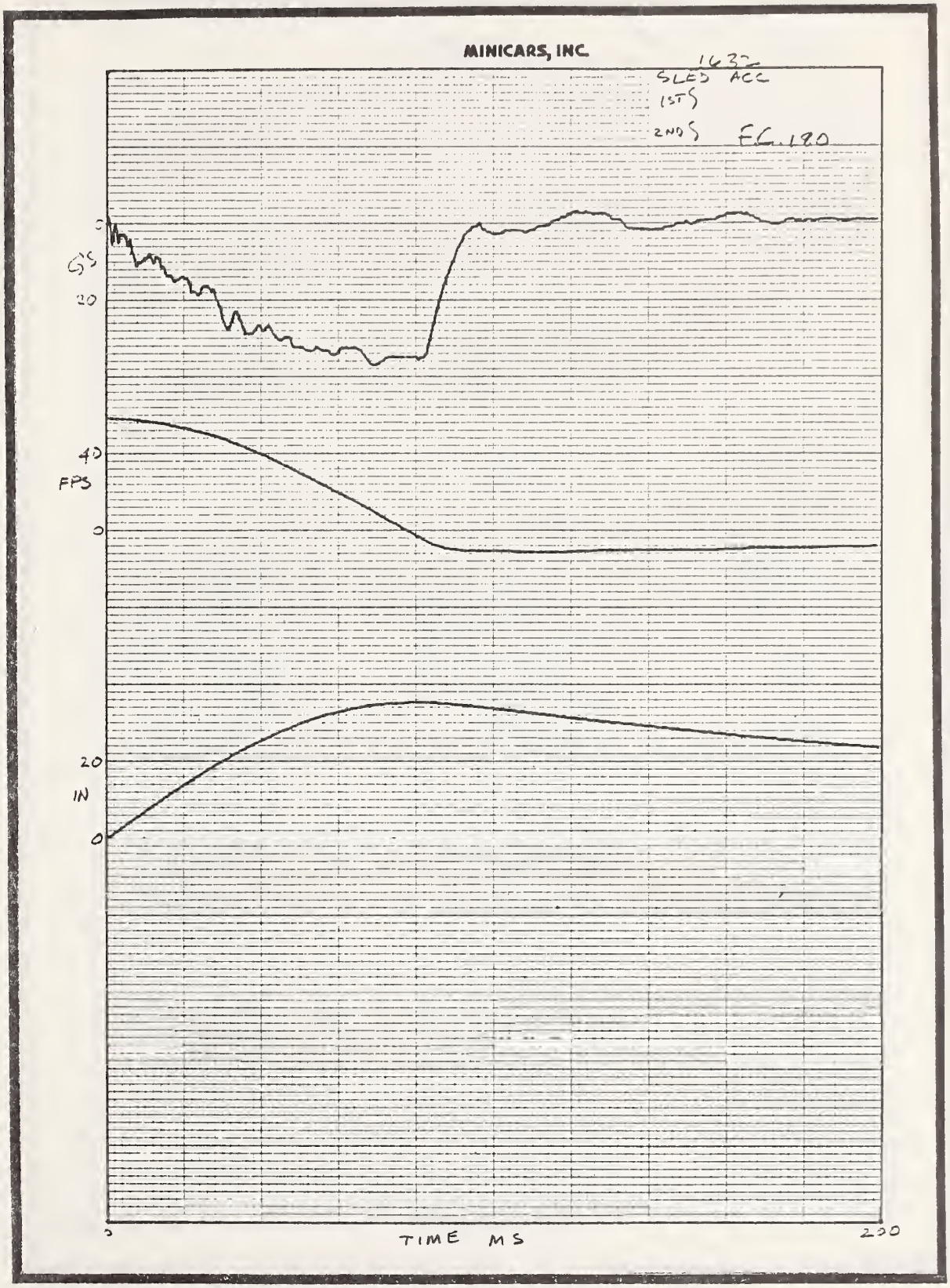

MINICARS, INC.
SQUIB CURRENT
(MILLI)
EC 200
0
0
TIME M.S.
200

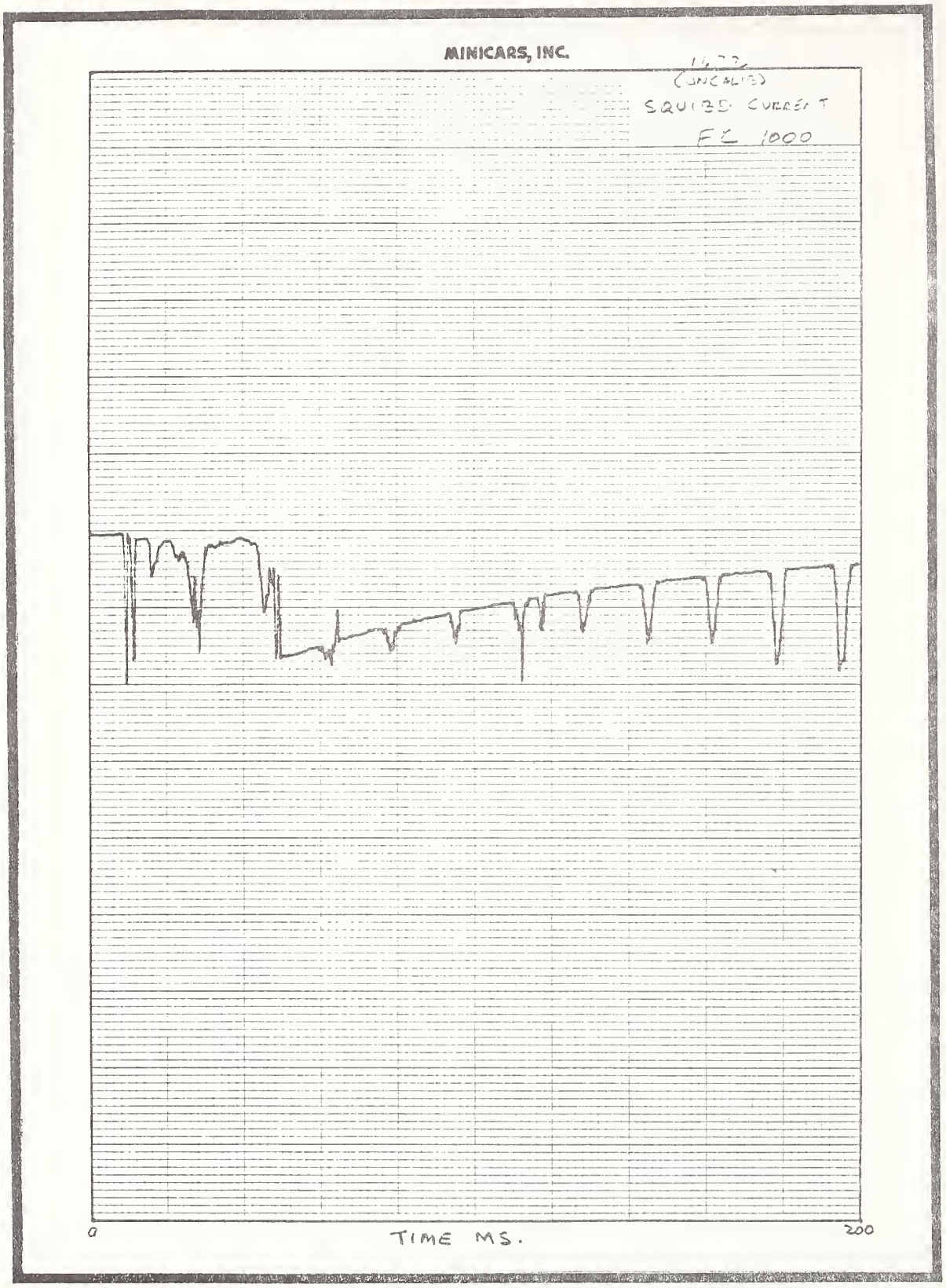

MINICARS, INC.
0
20
GS
0
0
TIME M.S.

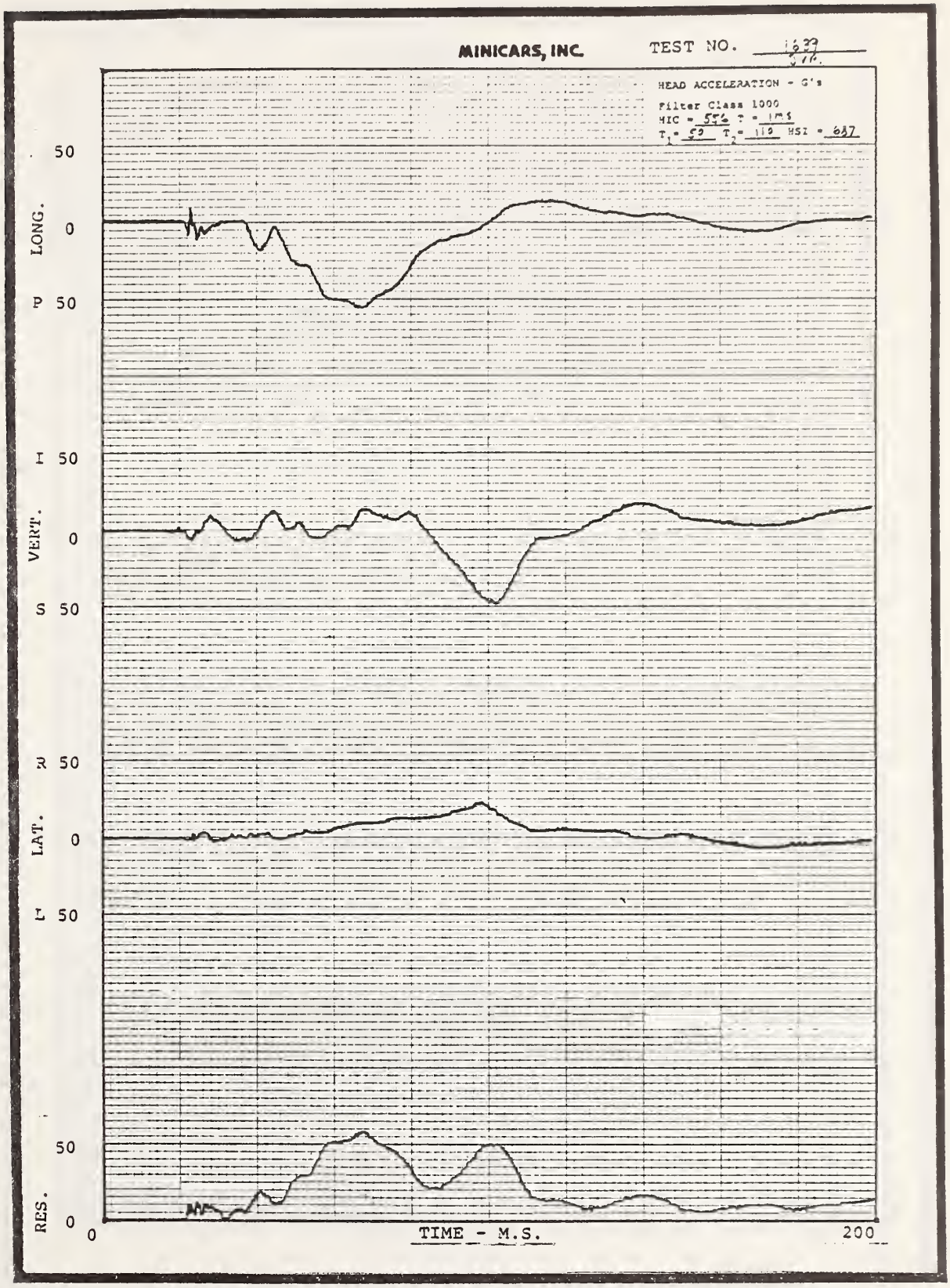

MINICARS, INC.
TEST NO. 1632
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 36 T = 1MS
T1 = 52 T2 = 96 HSI = 133
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

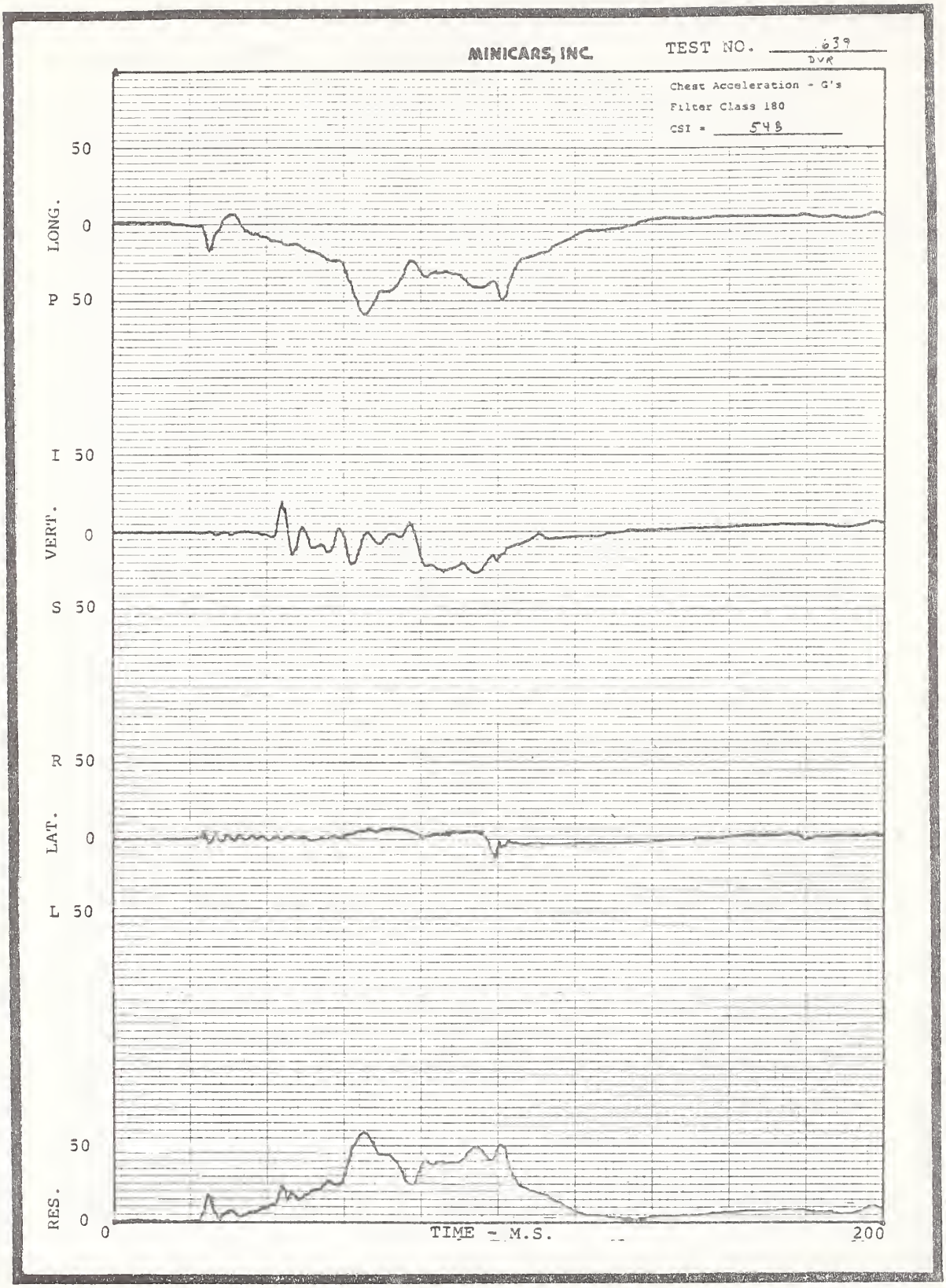

MINICARS, INC.
TEST NO.
Chest Acceleration - G's
Filter Class 180
CSI = 480
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

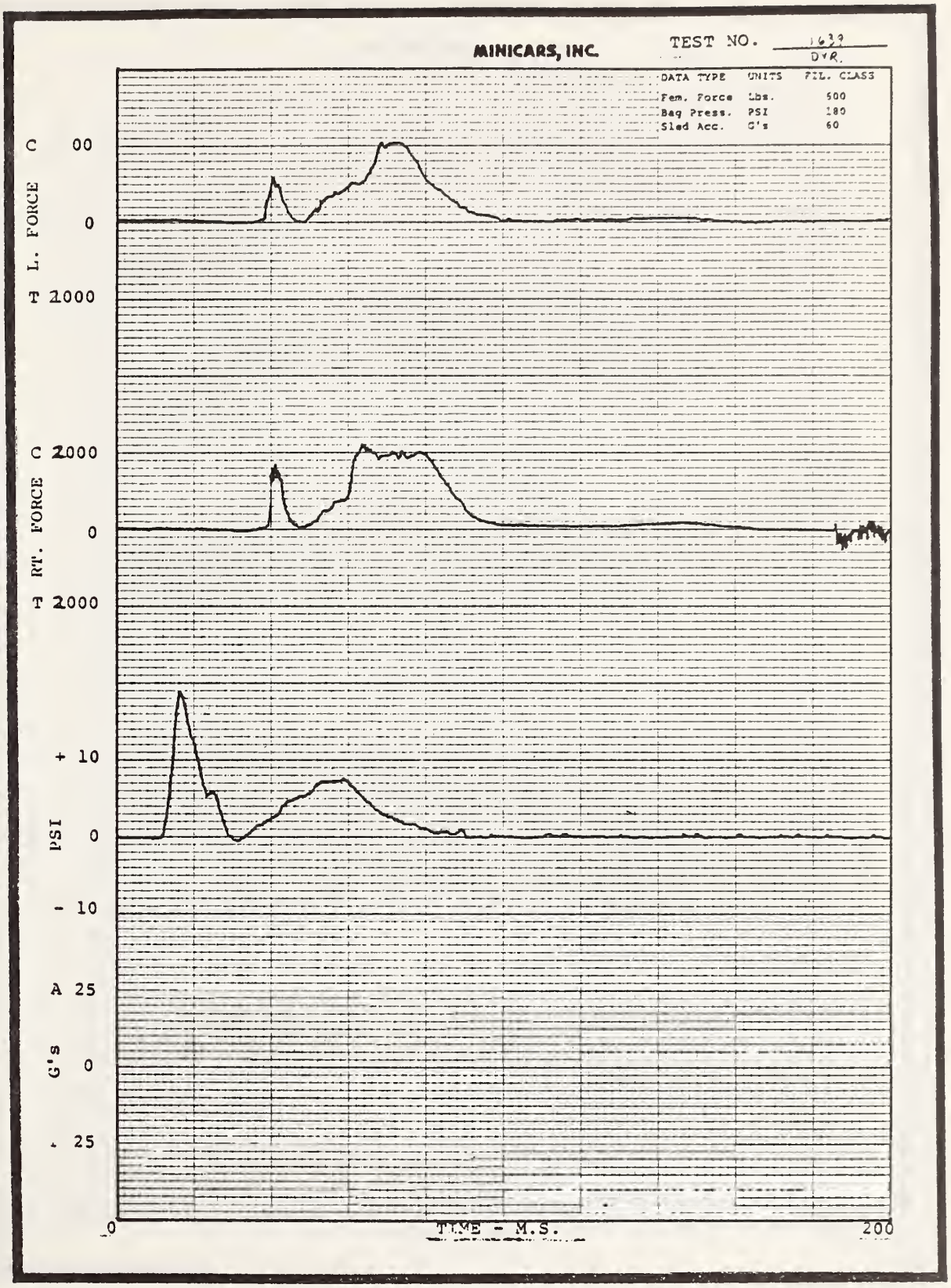

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
L. FORCE
RT. FORCE
PSI
G's
0
TIME - M.S.
200

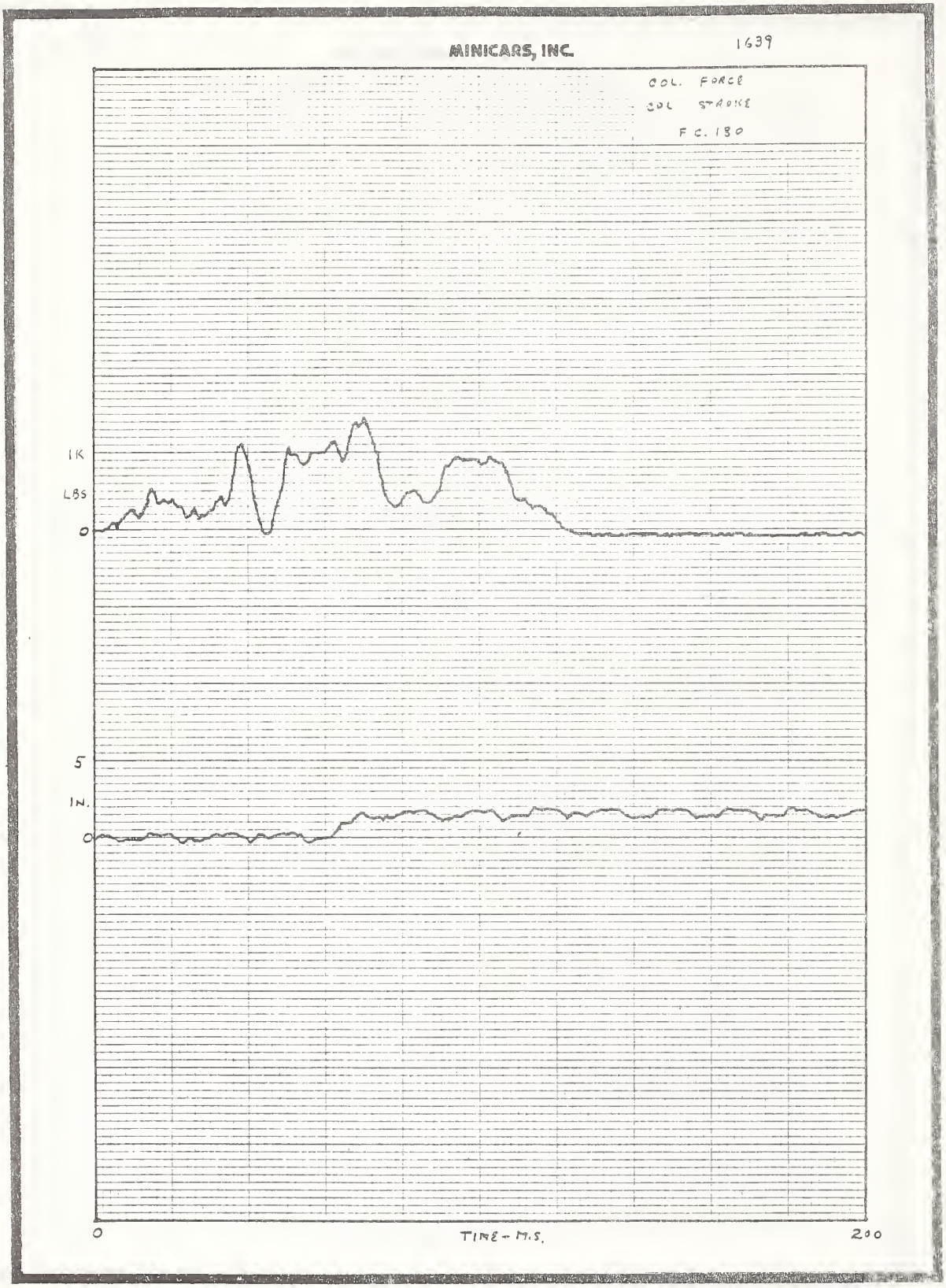

MINICARS, INC.
1630
SLED ACC
1ST
2ND
FG. 180
G'S
20
40
FPS
0
20
IN
0
0
TIME MS
200

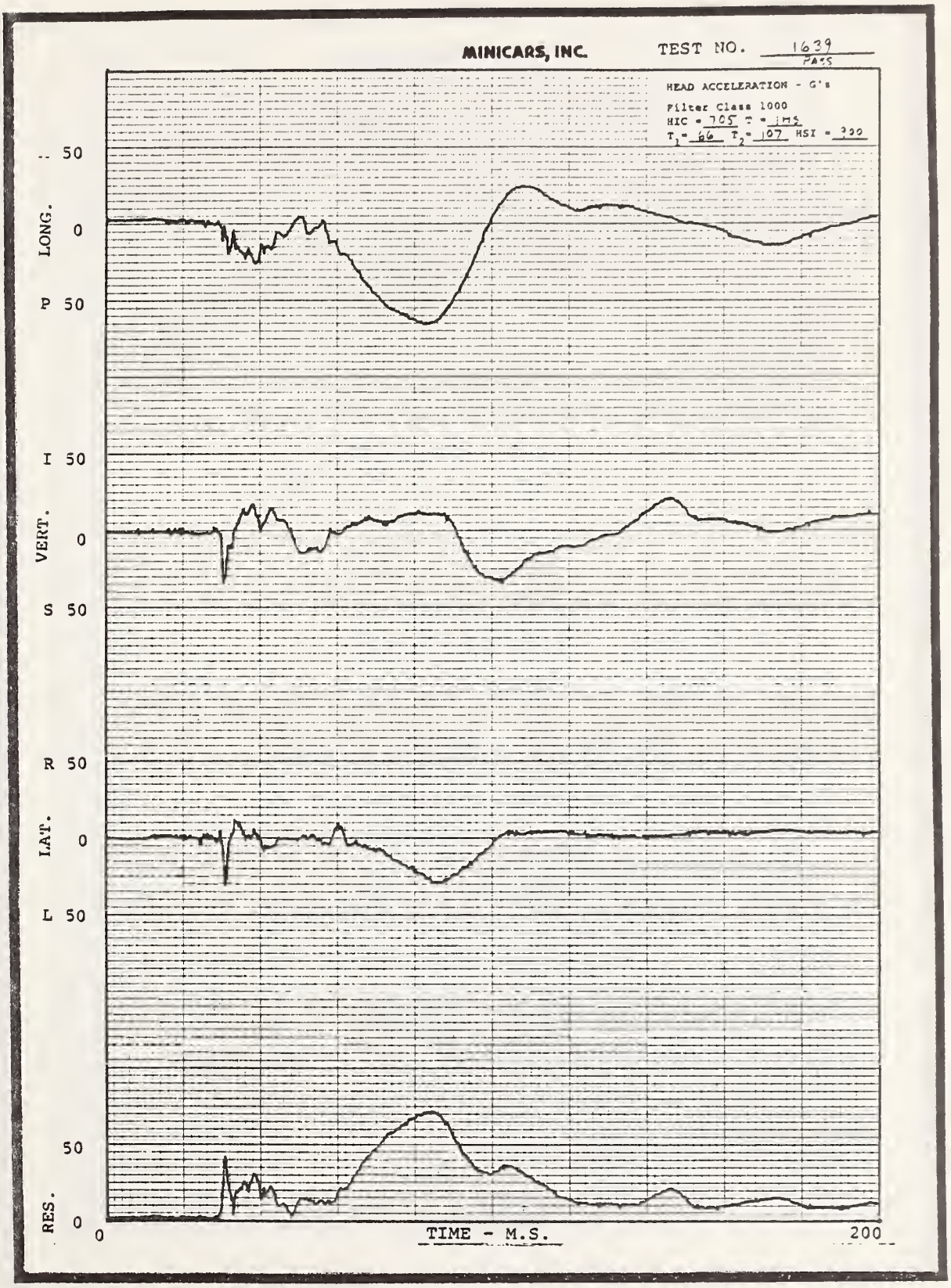

MINICARS, INC.
(UNCALIB)
SQUIBS CURRENT
FC 1000
0
TIME MS.
200

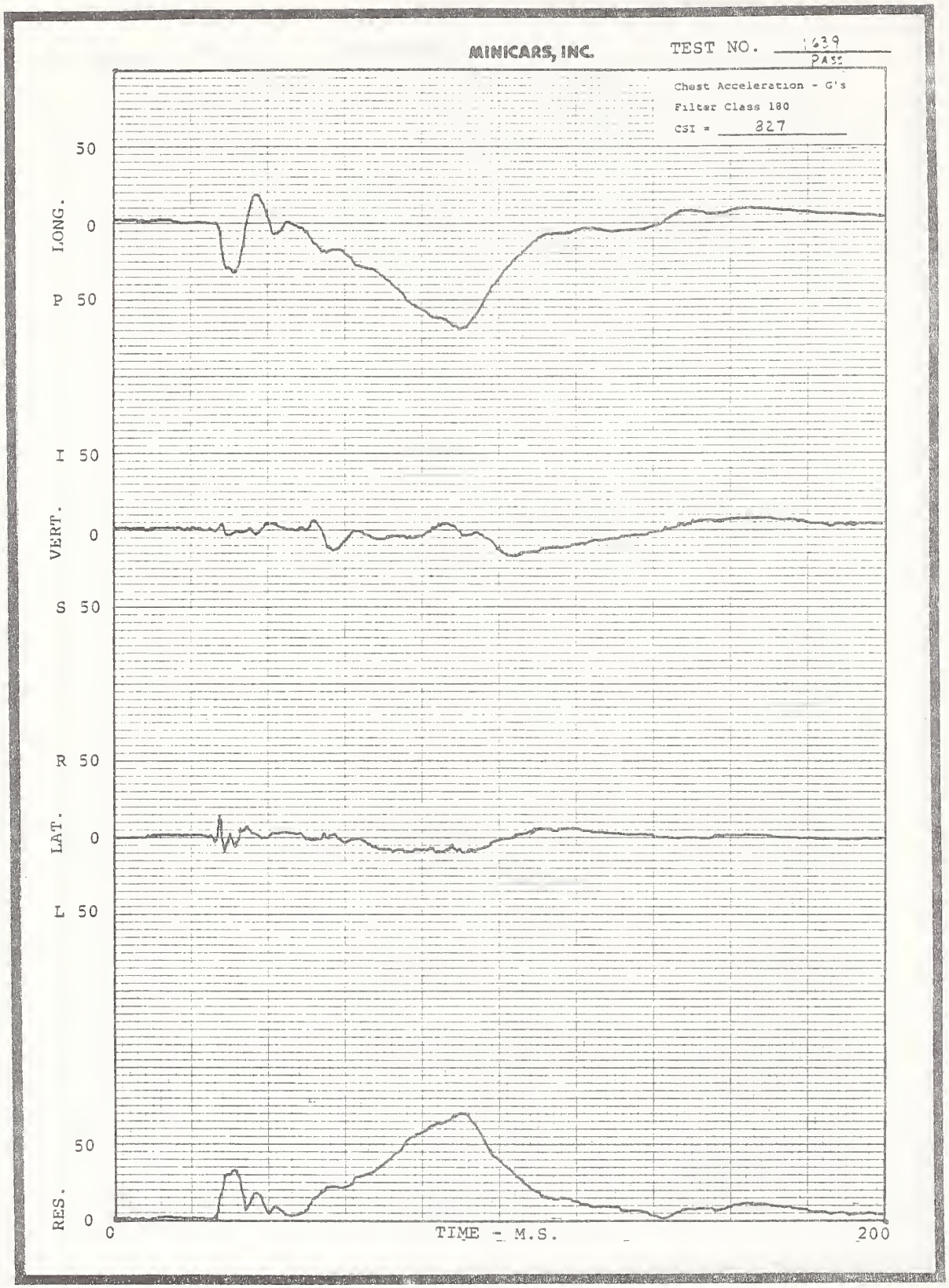

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 556 T = 1ms
T1 = 59 T2 = 119 HSI = 687
LONG.
VERT.
LAT.
RES.
50
0
TIME - M.S.
200

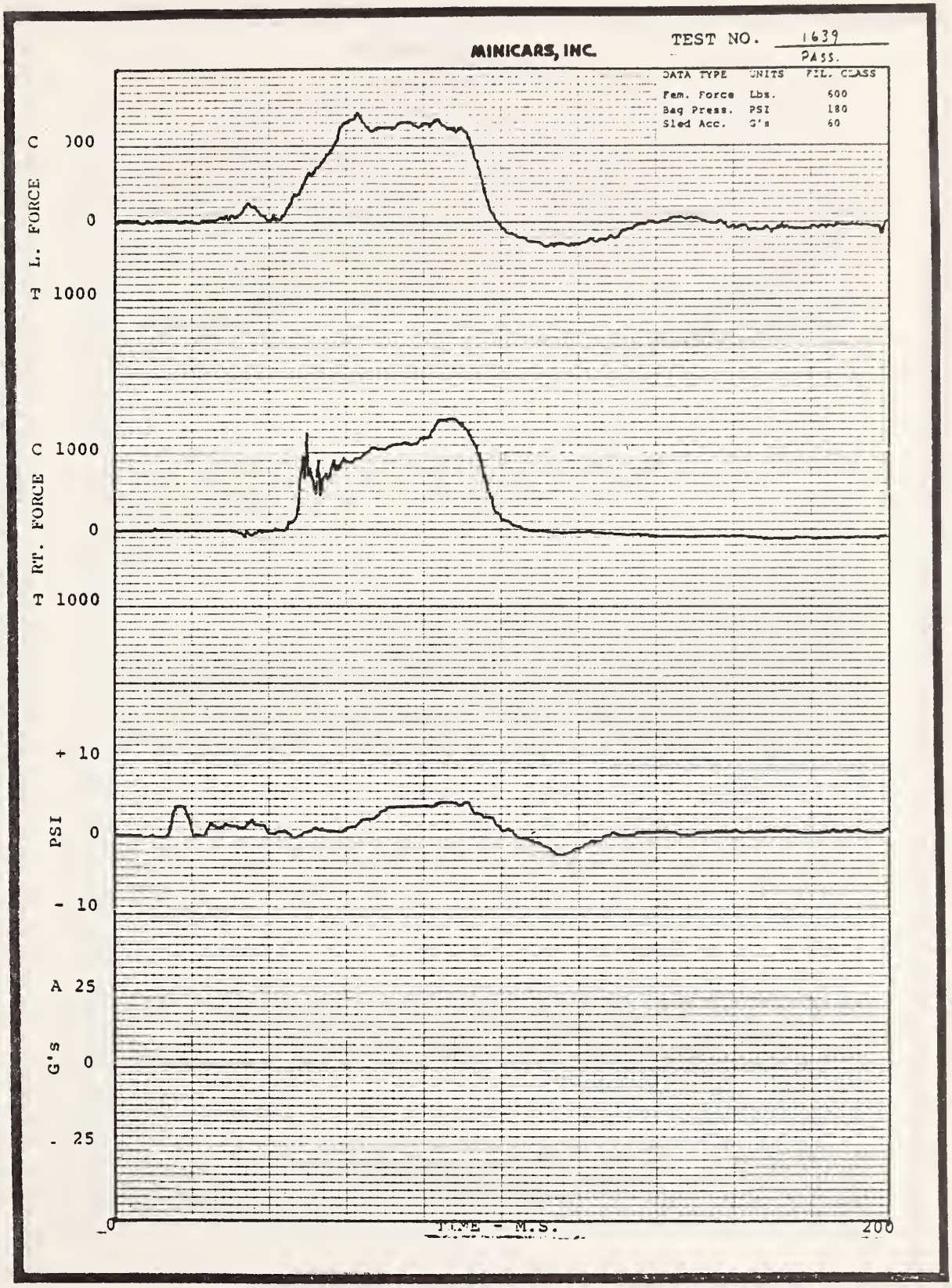

MINICARS, INC.
TEST NO. 639
DVR
Chest Acceleration - G's
Filter Class 180
CSI = 548
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

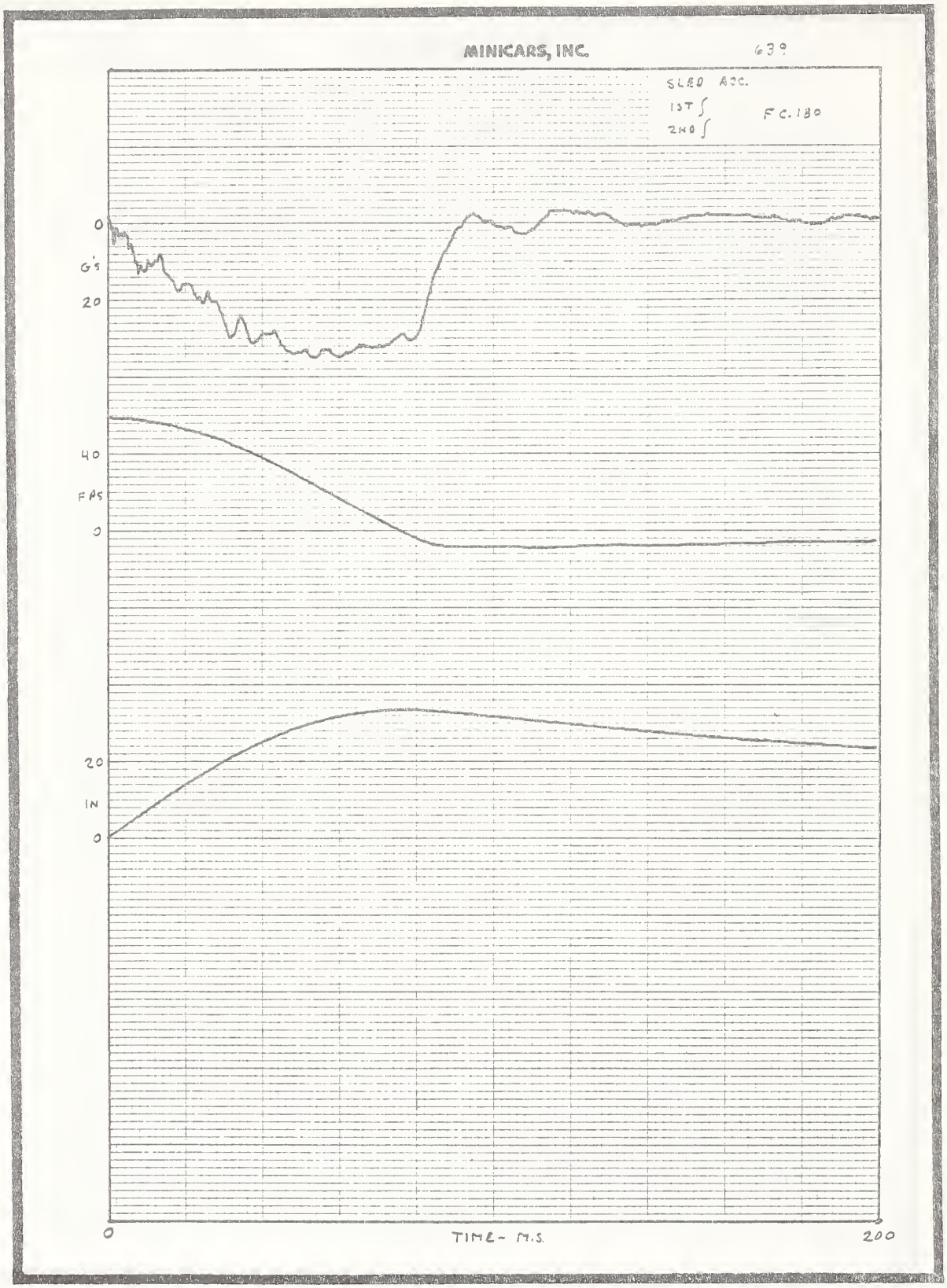

MINICARS, INC.
TEST NO. 1639 DYR.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 500
Bag Press. PSI 180
Sled Acc. G's 60
C 00
L. FORCE
T 2000
C 2000
RT. FORCE
T 2000
+ 10
PSI
0
- 10
A 25
G's
0
- 25
0
TIME - M.S.
200

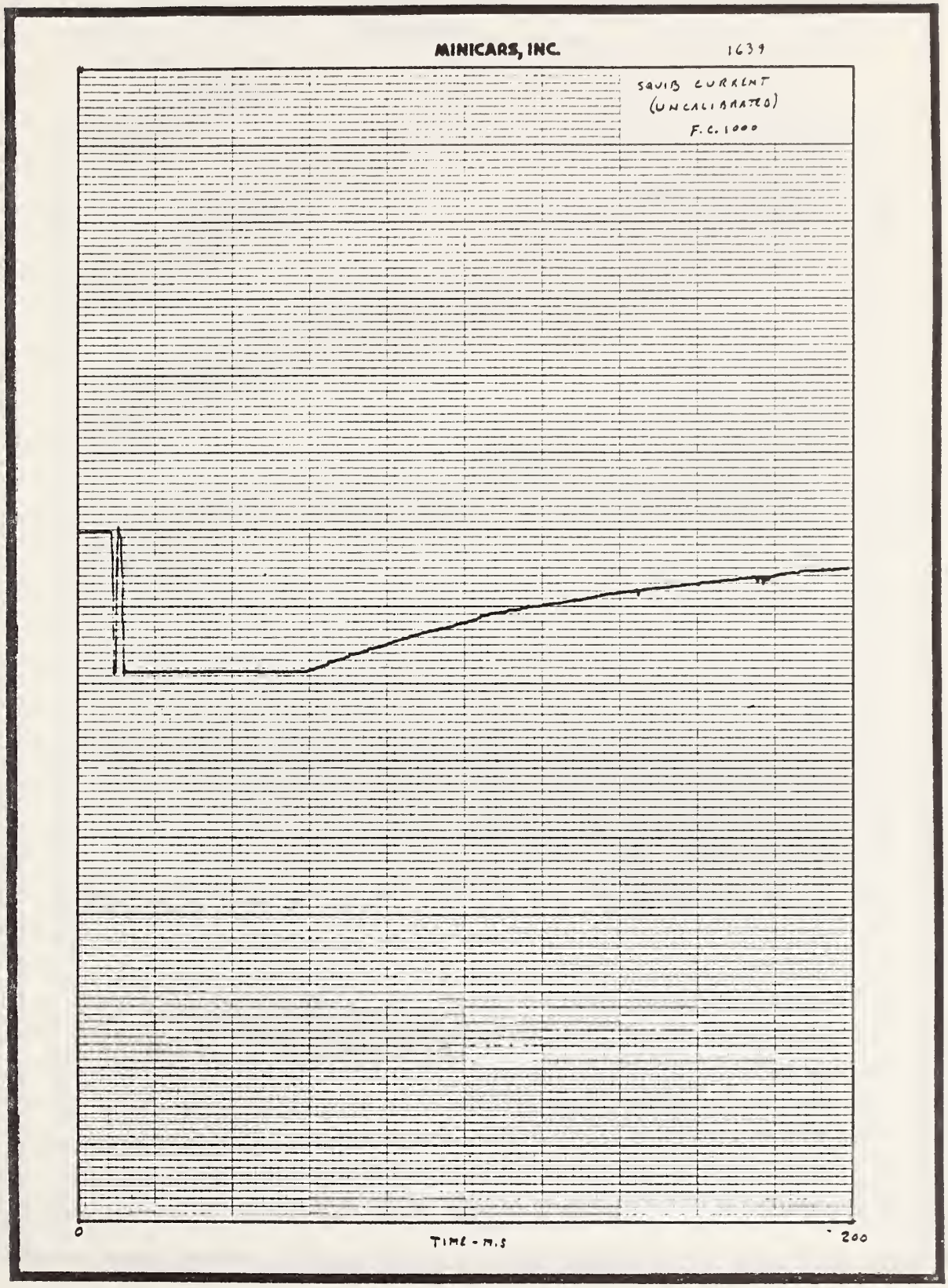

MINICARS, INC.
1639
COL. FORCE
COL STROKE
F C. 180
1K
LBS
0
5
IN.
0
0
TIME - M.S.
200

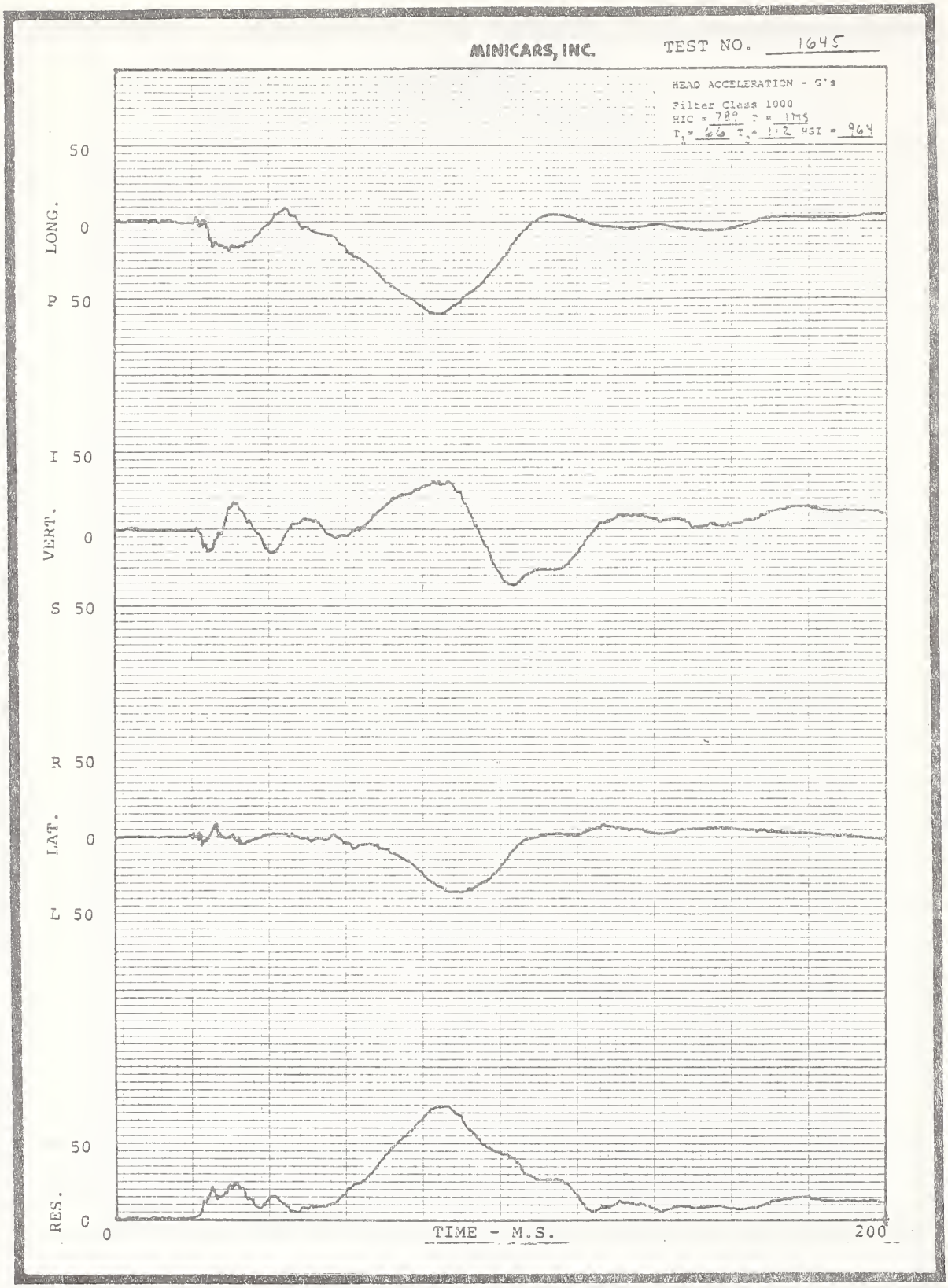

MINICARS, INC.
TEST NO. 1639
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 705 τ = 1ms
T1 = 66 T2 = 107 HSI = 300
LONG.
P 50
0
VERT.
I 50
S 50
0
LAT.
R 50
L 50
0
RES.
50
0
0
TIME - M.S.
200

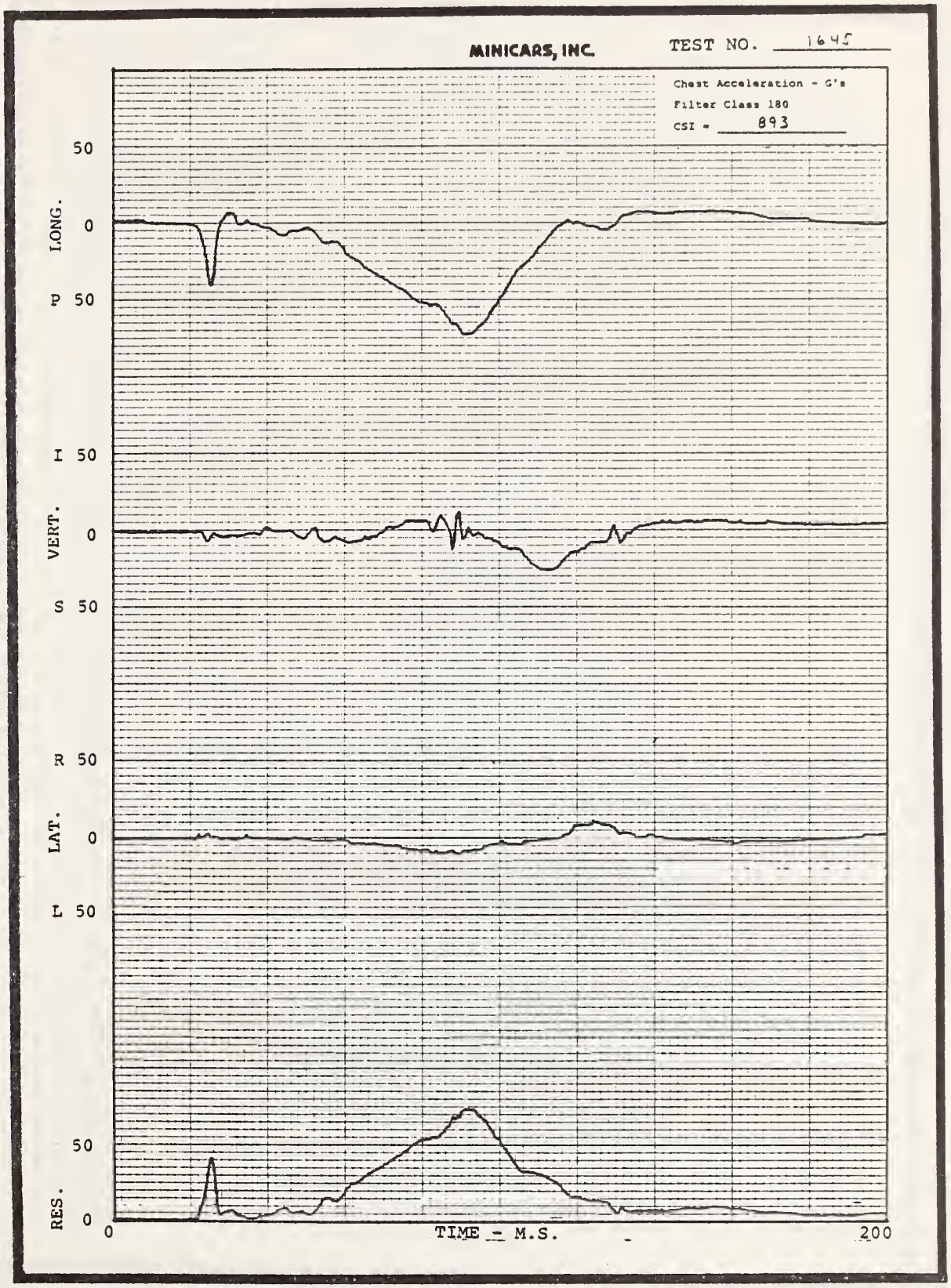

MINICARS, INC.
TEST NO. 1639 PASS
Chest Acceleration - G's
Filter Class 180
CSI = 827
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

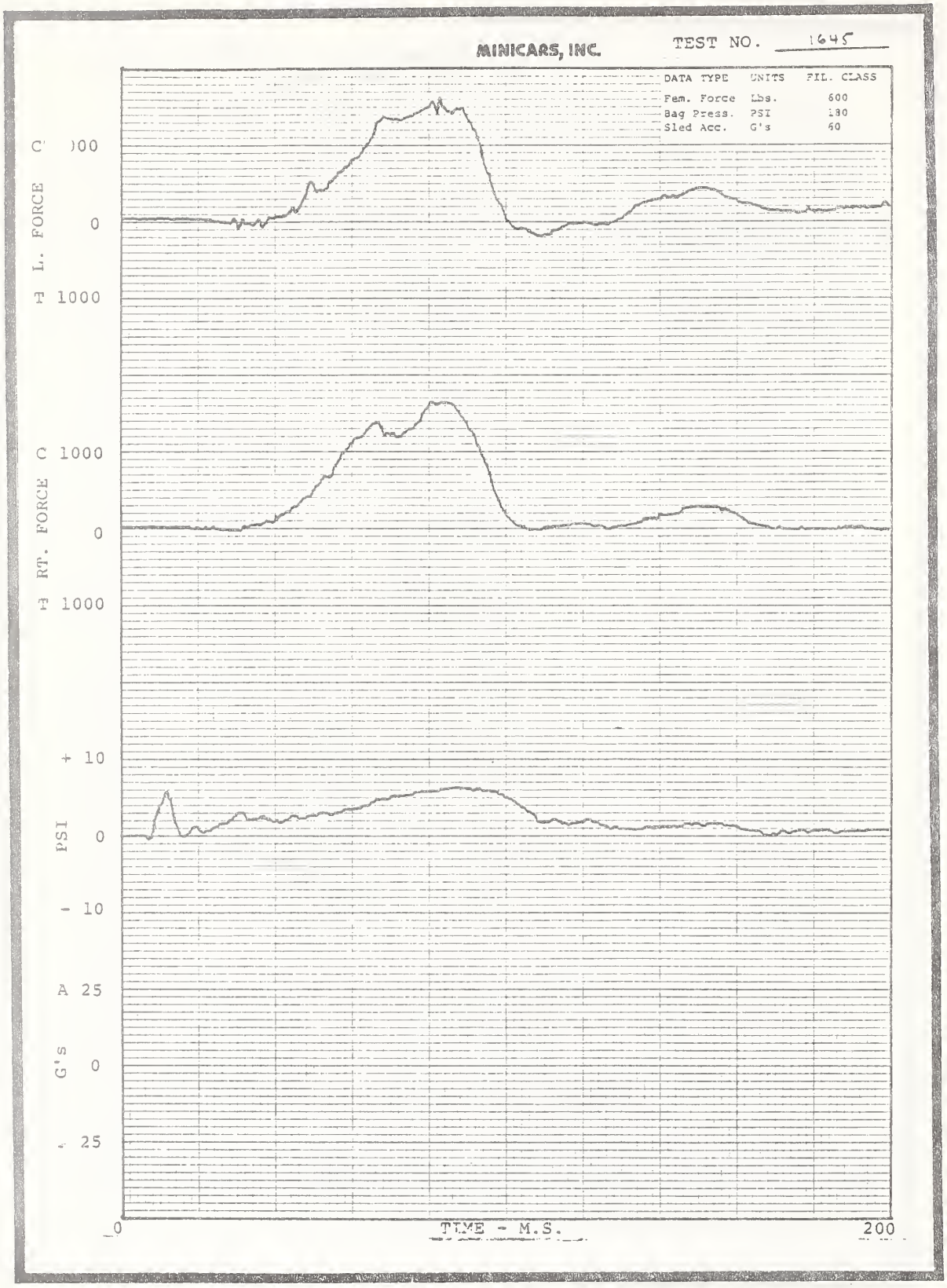

MINICARS, INC.
TEST NO. 1639
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 000
0
T 1000
L. FORCE
C 1000
0
T 1000
RT. FORCE
+ 10
PSI 0
- 10
A 25
G's 0
- 25
0
TIME - M.S.
200

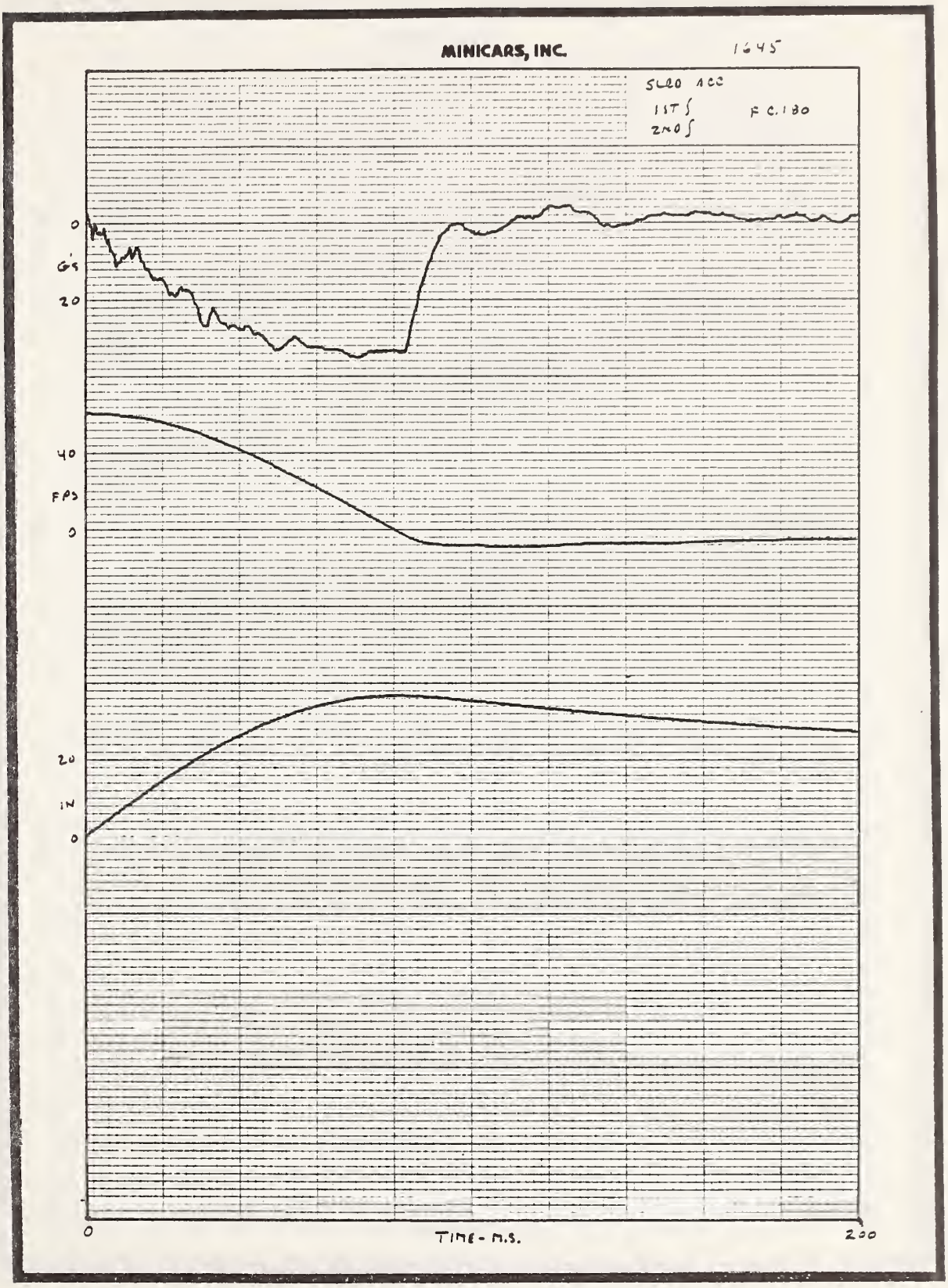

MINICARS, INC.
639
SLED ACC.
1ST ∫
2ND ∫
FC.180
0
G'S
20
40
FPS
0
20
IN
0
0
TIME - M.S.
200

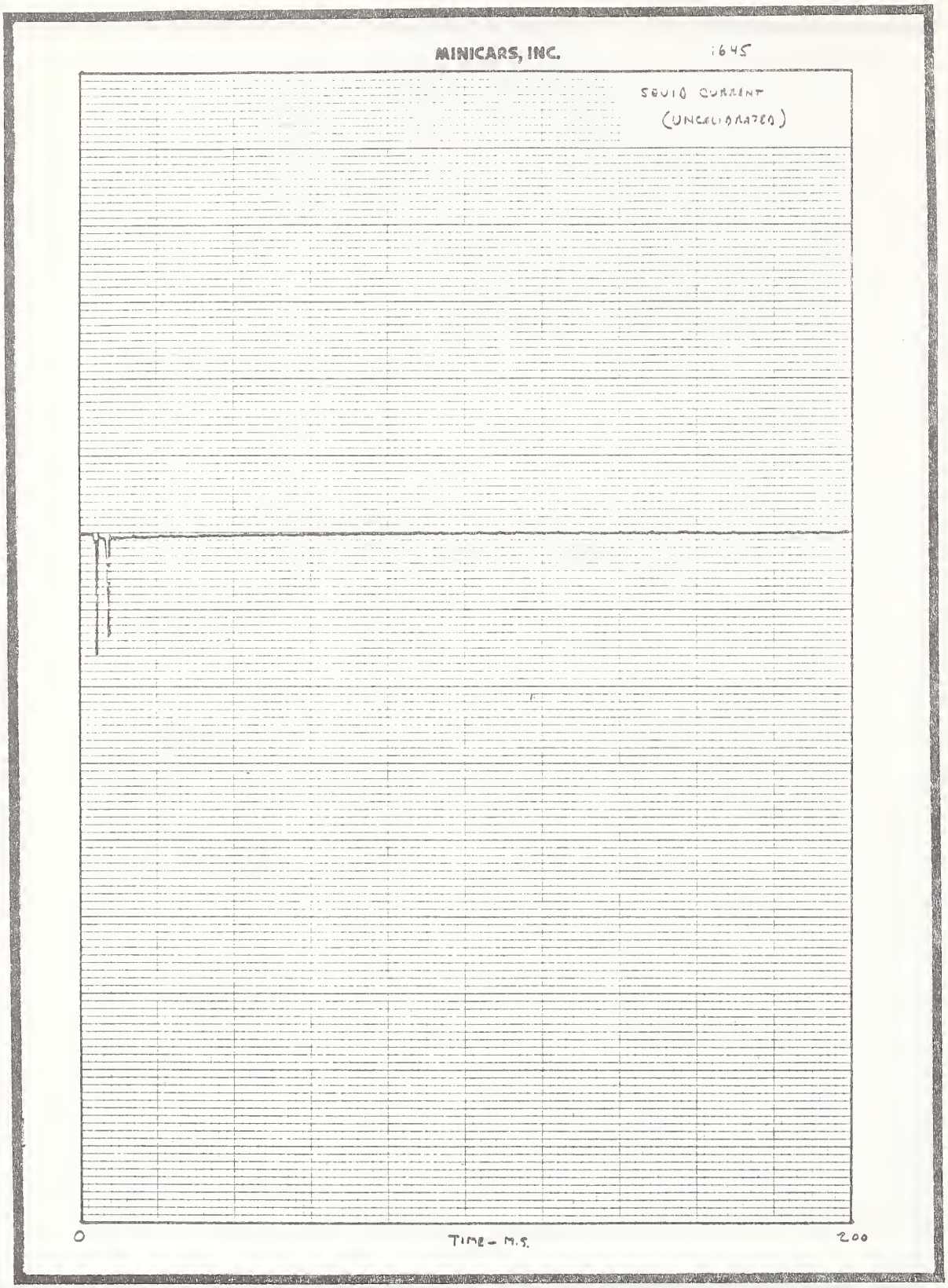

MINICARS, INC.
1639
SQUIB CURRENT
(UNCALIBRATED)
F.C. 1000
0
TIME - M.S
200

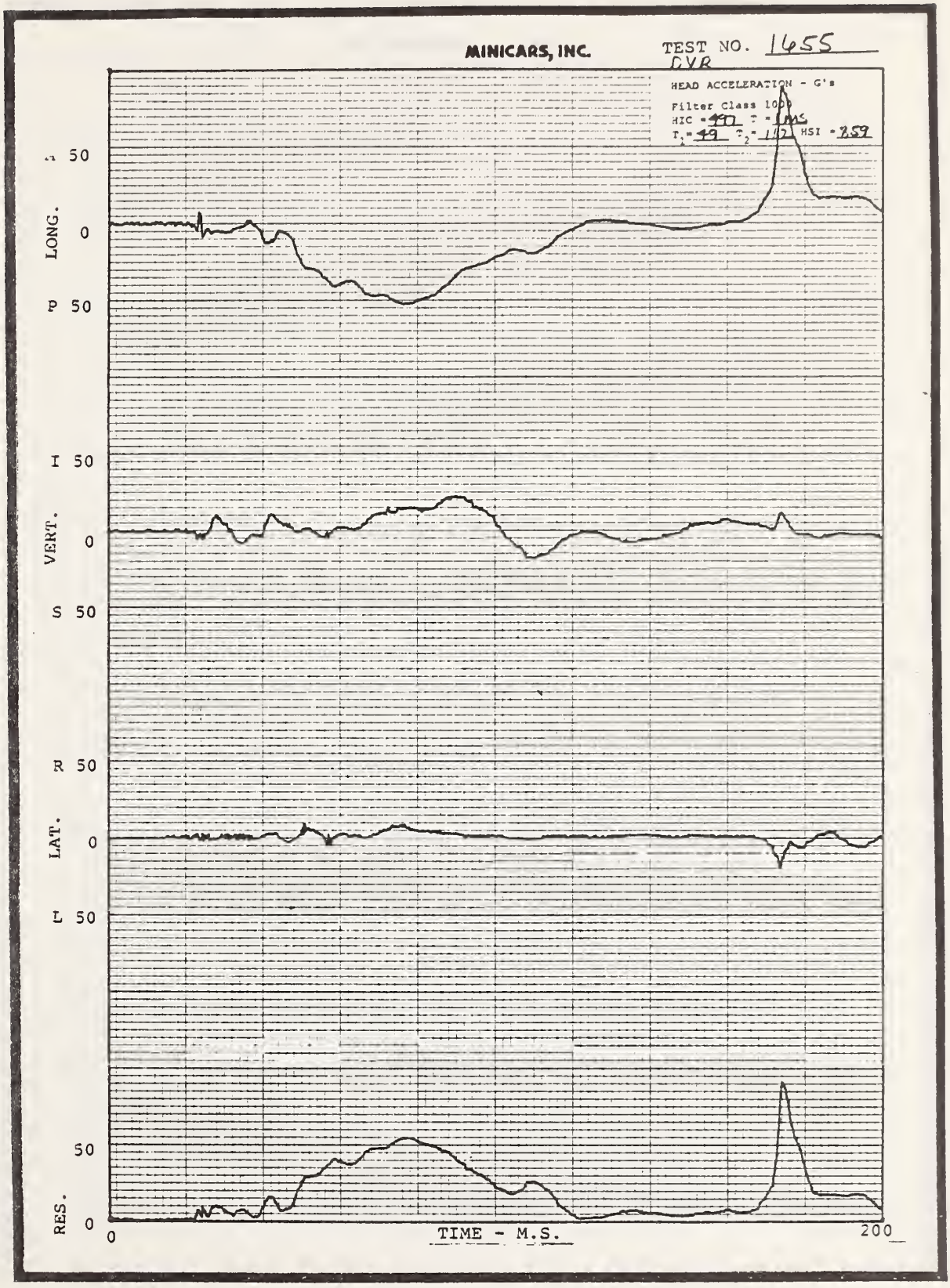

MINICARS, INC.
TEST NO. 1645
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 789 τ = 1MS
T1 = 66 T2 = 112 HSI = 964
LONG.
VERT.
LAT.
RES.
50
0
P 50
I 50
S 50
R 50
L 50
0
TIME - M.S.
200

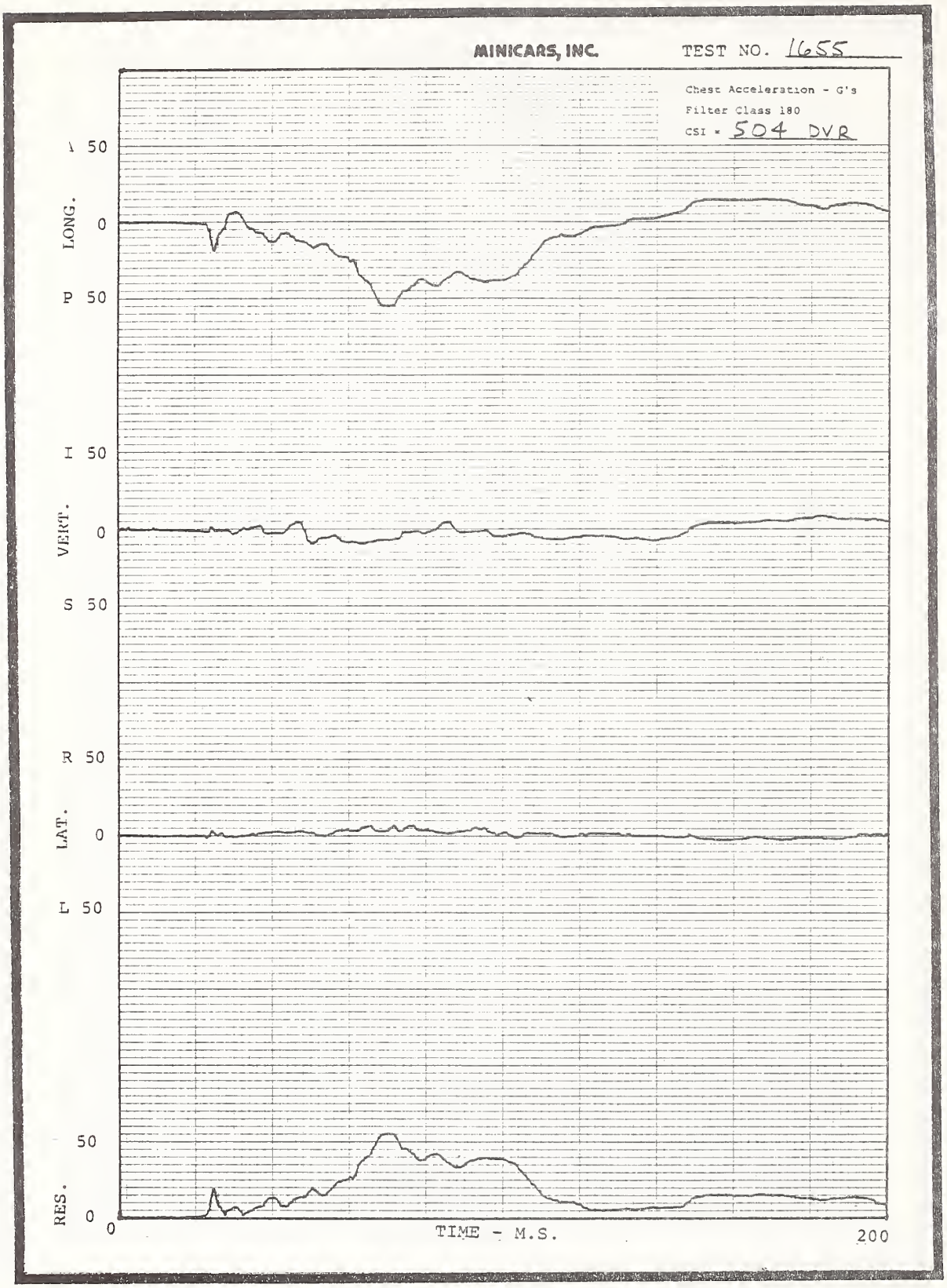

MINICARS, INC.
TEST NO. 1645
Chest Acceleration - G's
Filter Class 180
CSI = 893
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

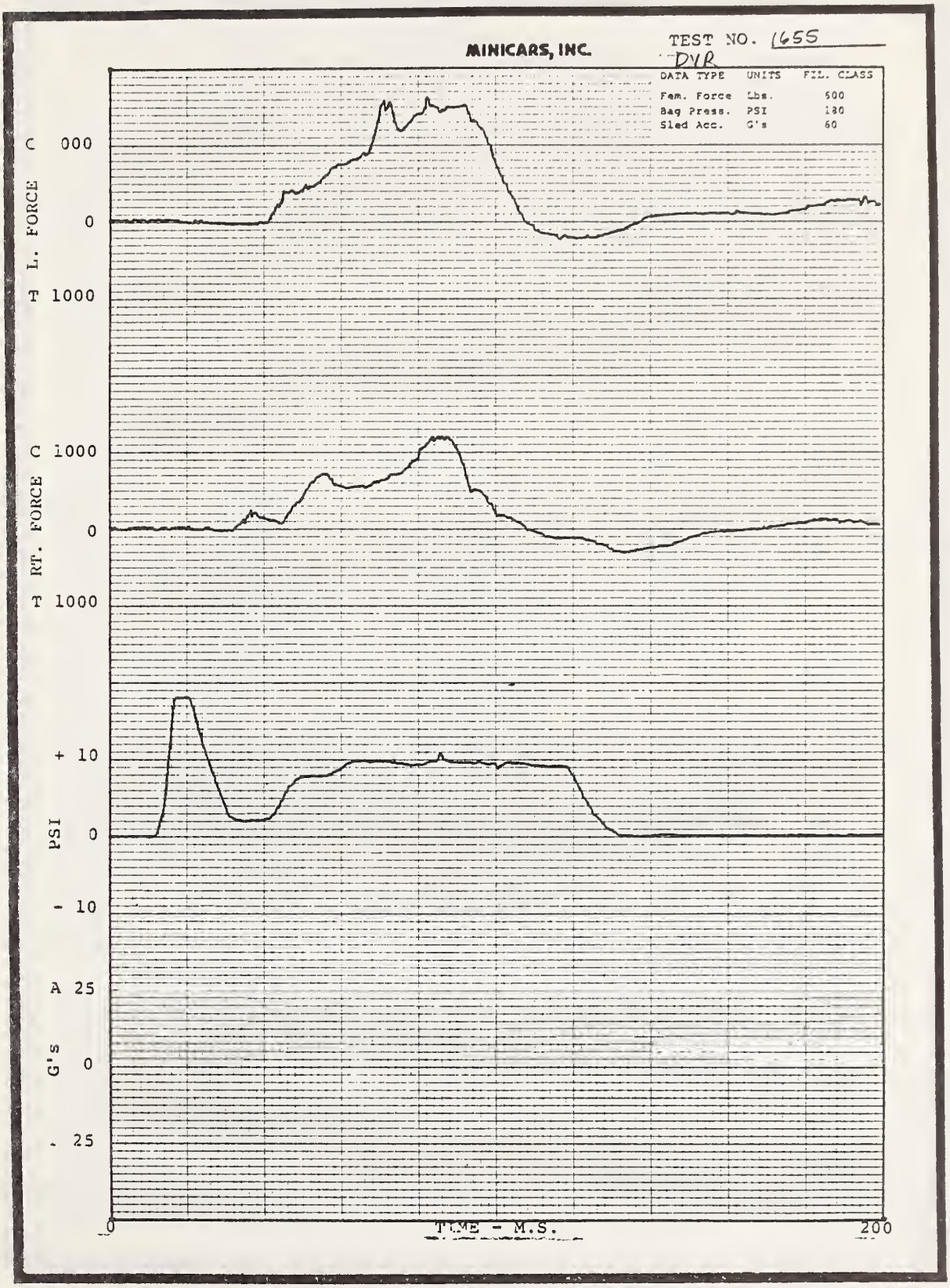

MINICARS, INC.
TEST NO. 1645
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
L. FORCE
0
1000
RT. FORCE
1000
0
1000
+ 10
PSI
0
- 10
A 25
G's
0
25
0
TIME - M.S.
200

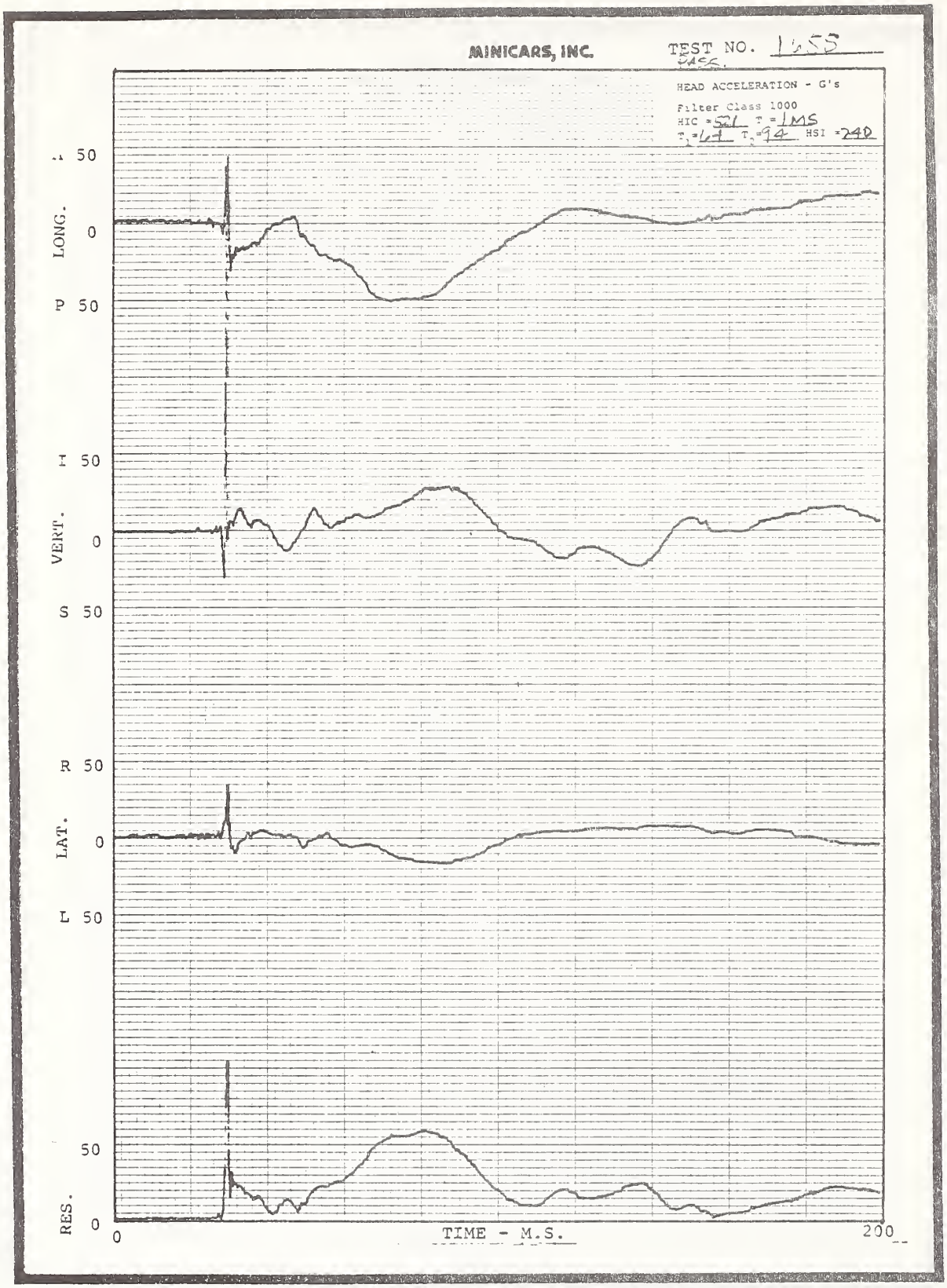

MINICARS, INC.
1645
SLED ACC
1ST ∫
2ND ∫
F C.180
0
G's
20
40
FPS
0
20
IN
0
0
TIME - M.S.
200

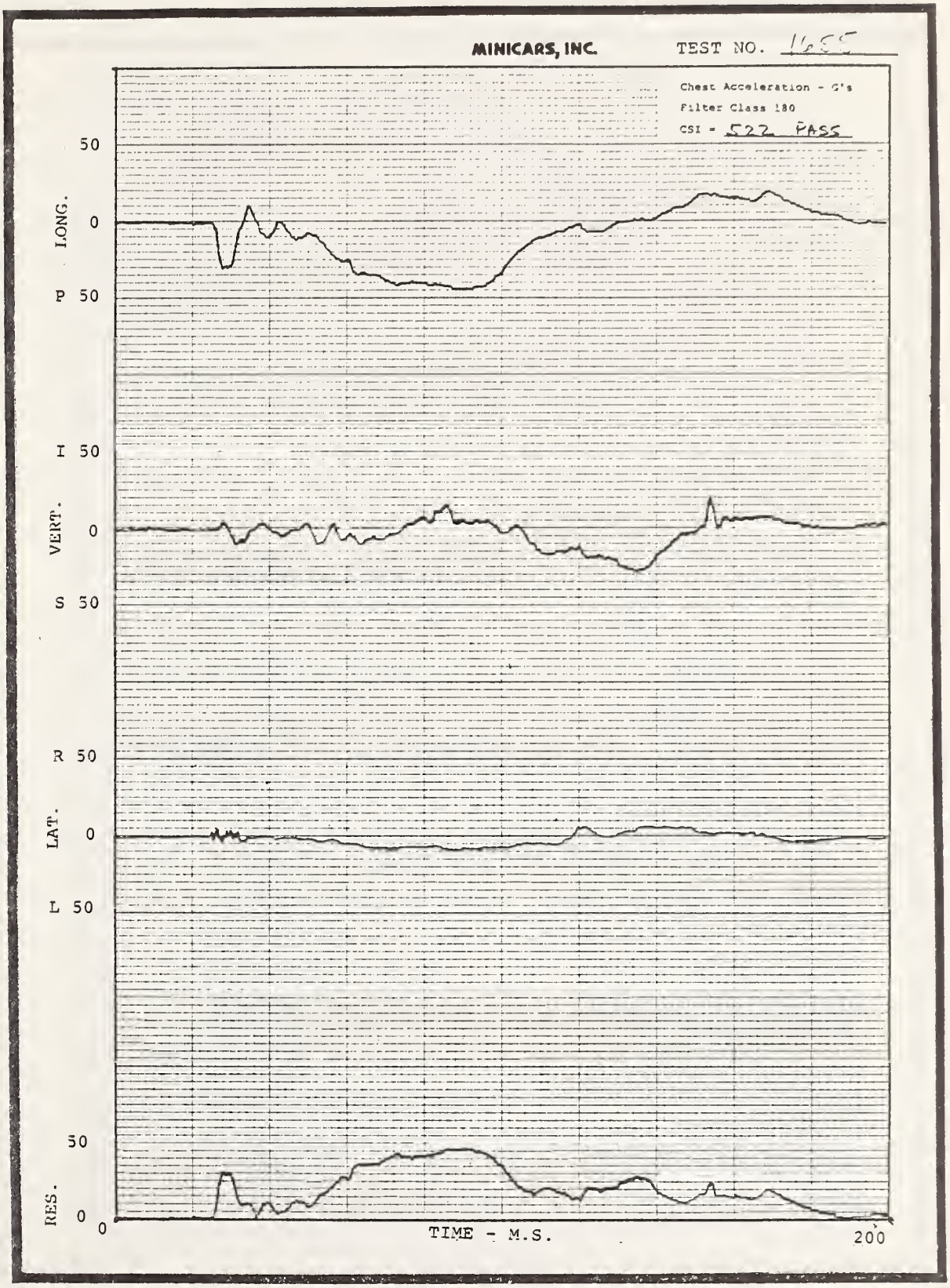

MINICARS, INC.
1645
SQUID CURRENT
(UNCALIBRATED)
0
TIME - M.S.
200

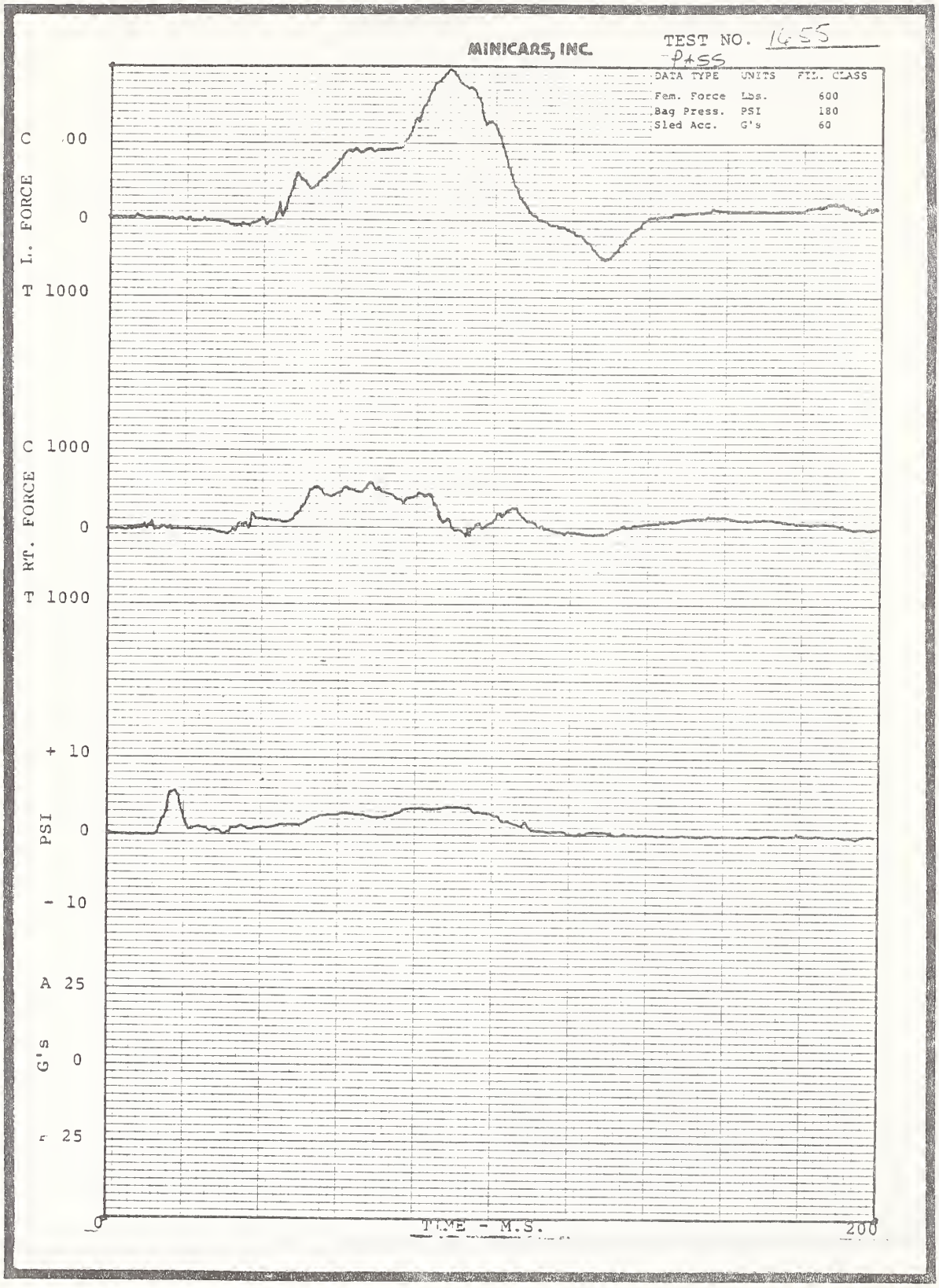

MINICARS, INC.
TEST NO. 1655
DVR
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 490 T = 1 MS
T1 = 49 T2 = 102 HSI = 259
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

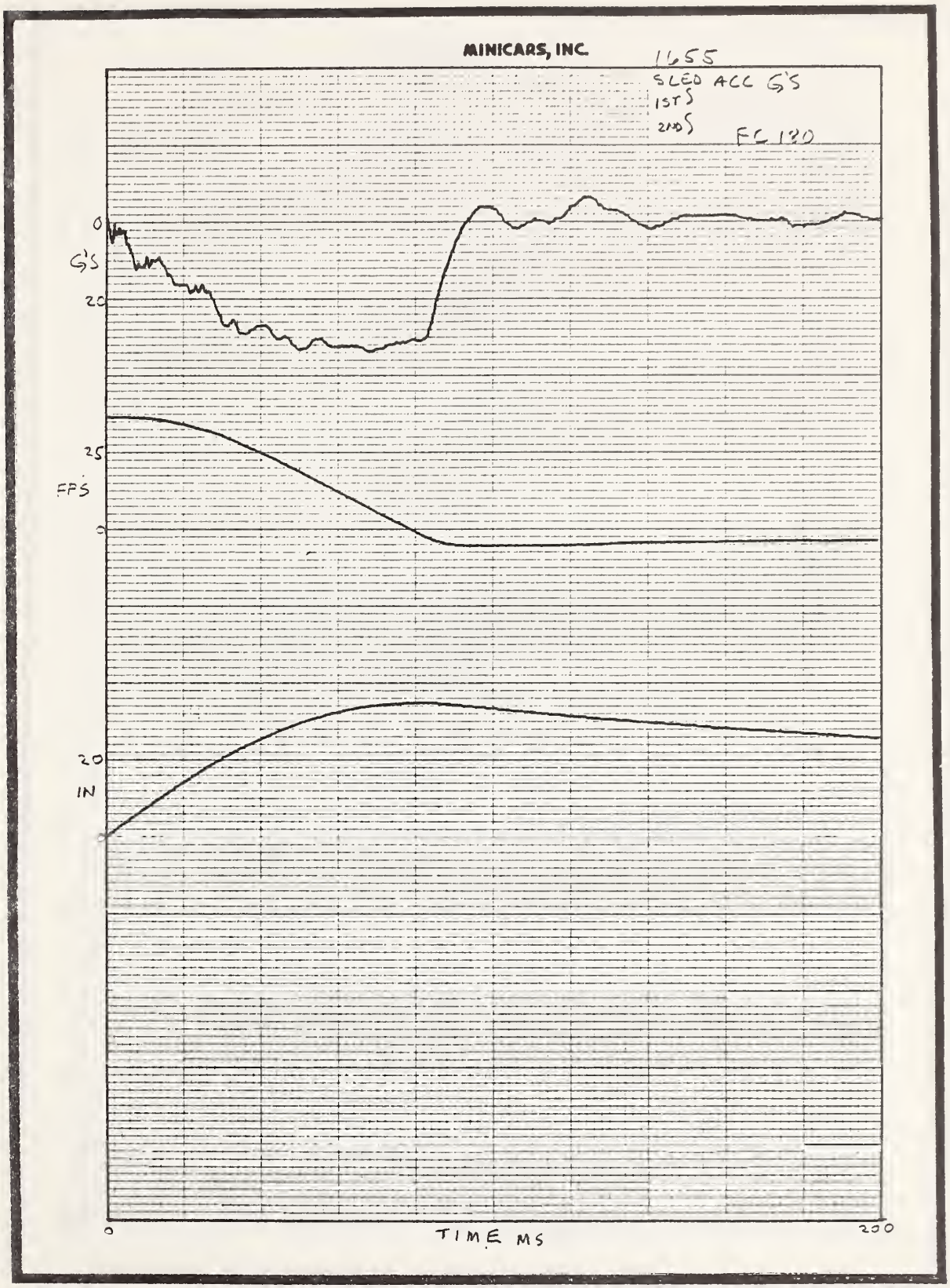

MINICARS, INC.
TEST NO. 1655
Chest Acceleration - G's
Filter Class 180
CSI = 504 DVR
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

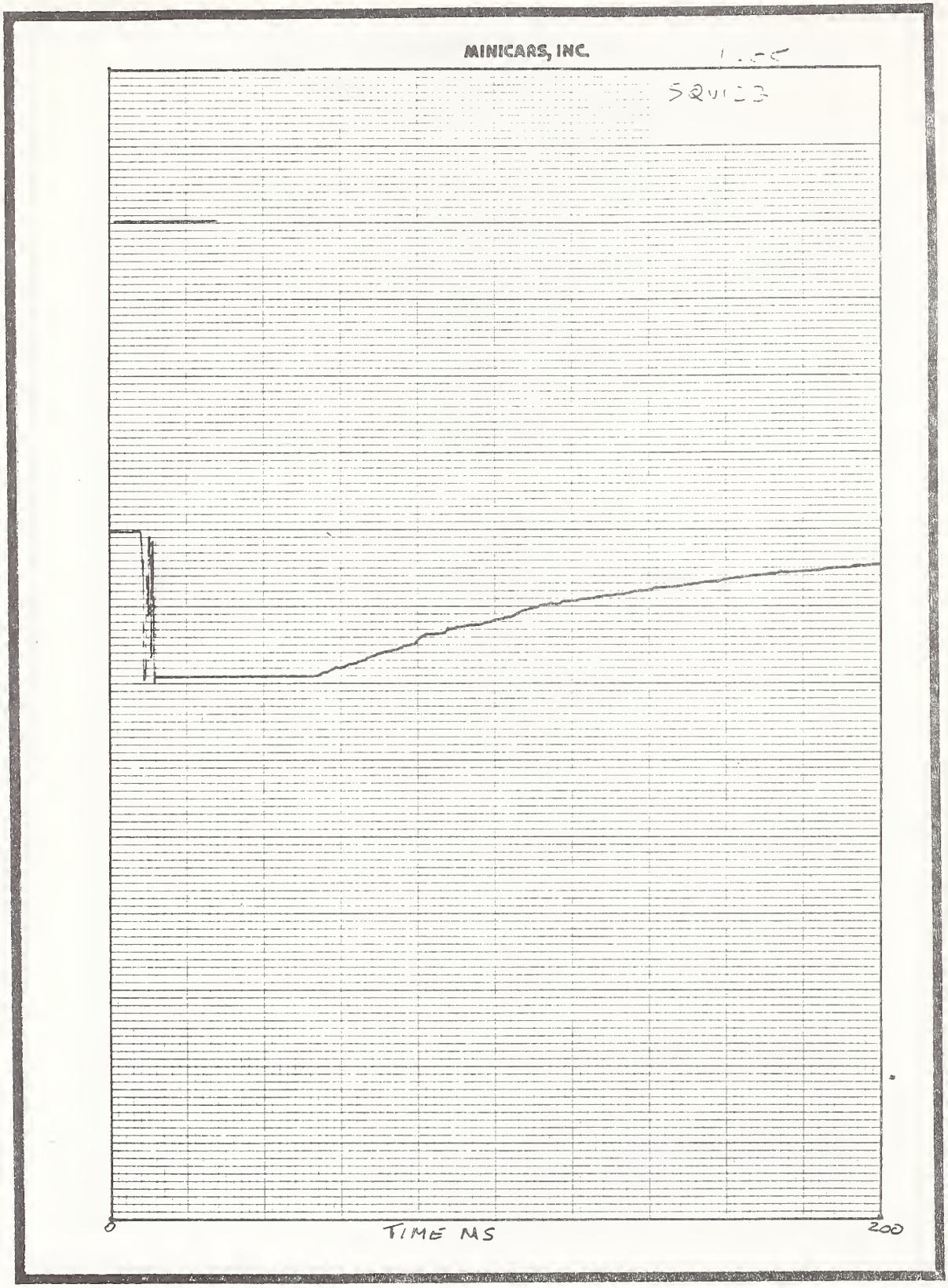

MINICARS, INC.
TEST NO. 1655
DVR
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 000
0
T 1000
L. FORCE
C 1000
0
T 1000
RT. FORCE
+ 10
0
- 10
PSI
A 25
0
- 25
G's
0
TIME - M.S.
200

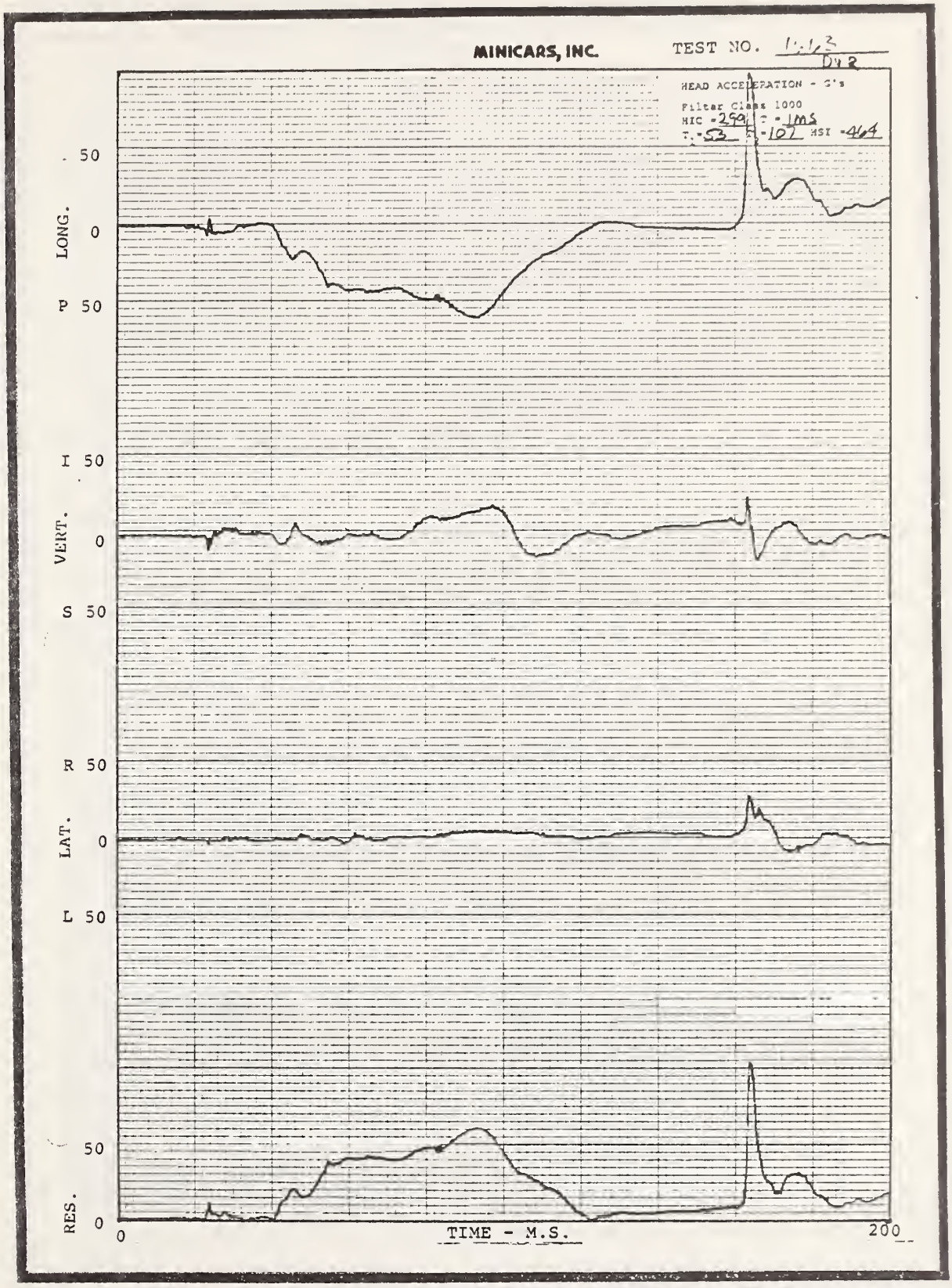

MINICARS, INC.
TEST NO. 1655
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 501 T = 1MS
T1 = 64 T2 = 94 HSI = 240
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

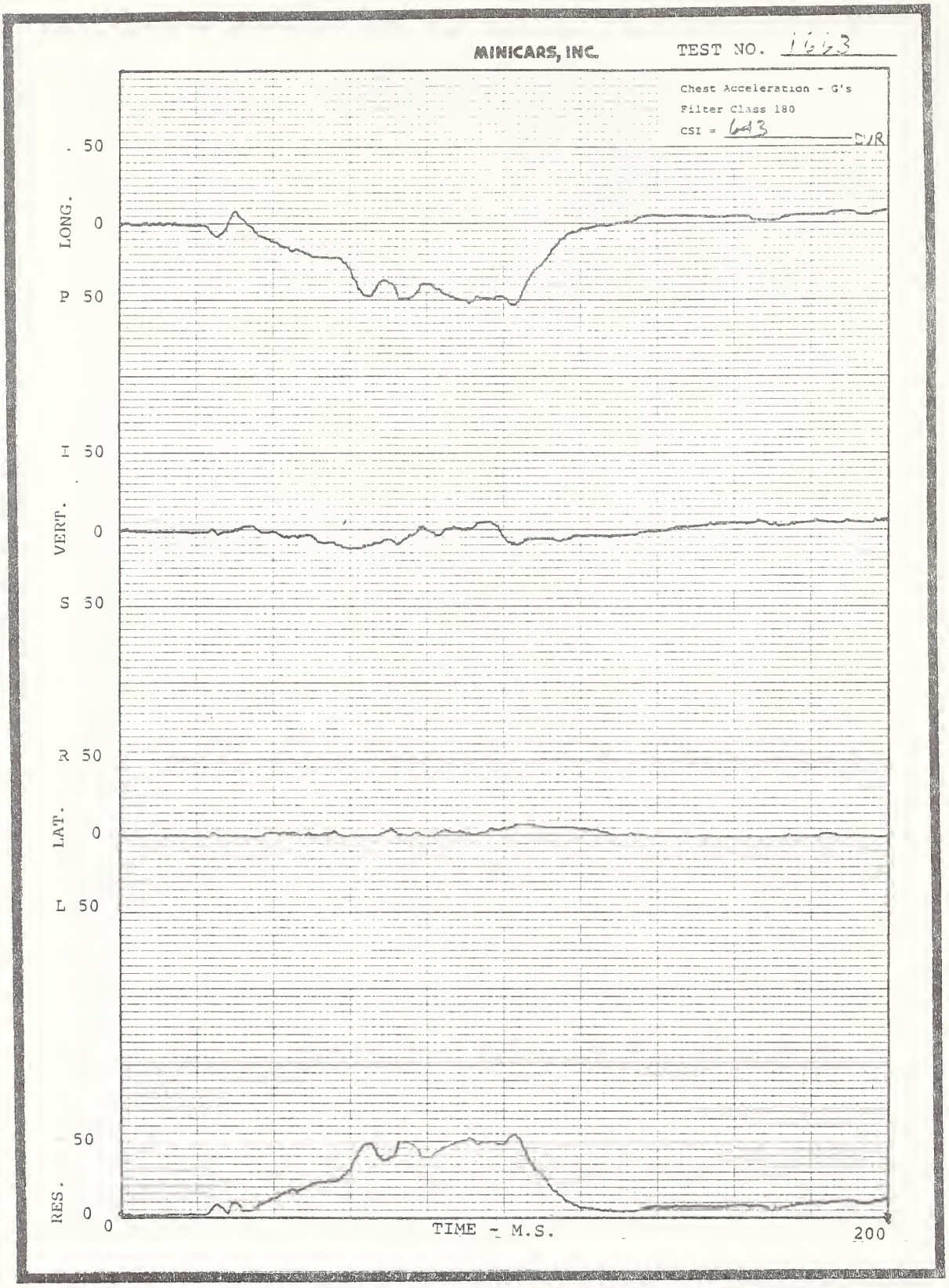

MINICARS, INC.
TEST NO. 1655
Chest Acceleration - G's
Filter Class 180
CSI = 522 PASS
LONG.
P 50
0
VERT.
I 50
0
S 50
LAT.
R 50
0
L 50
RES.
50
0
0
TIME - M.S.
200

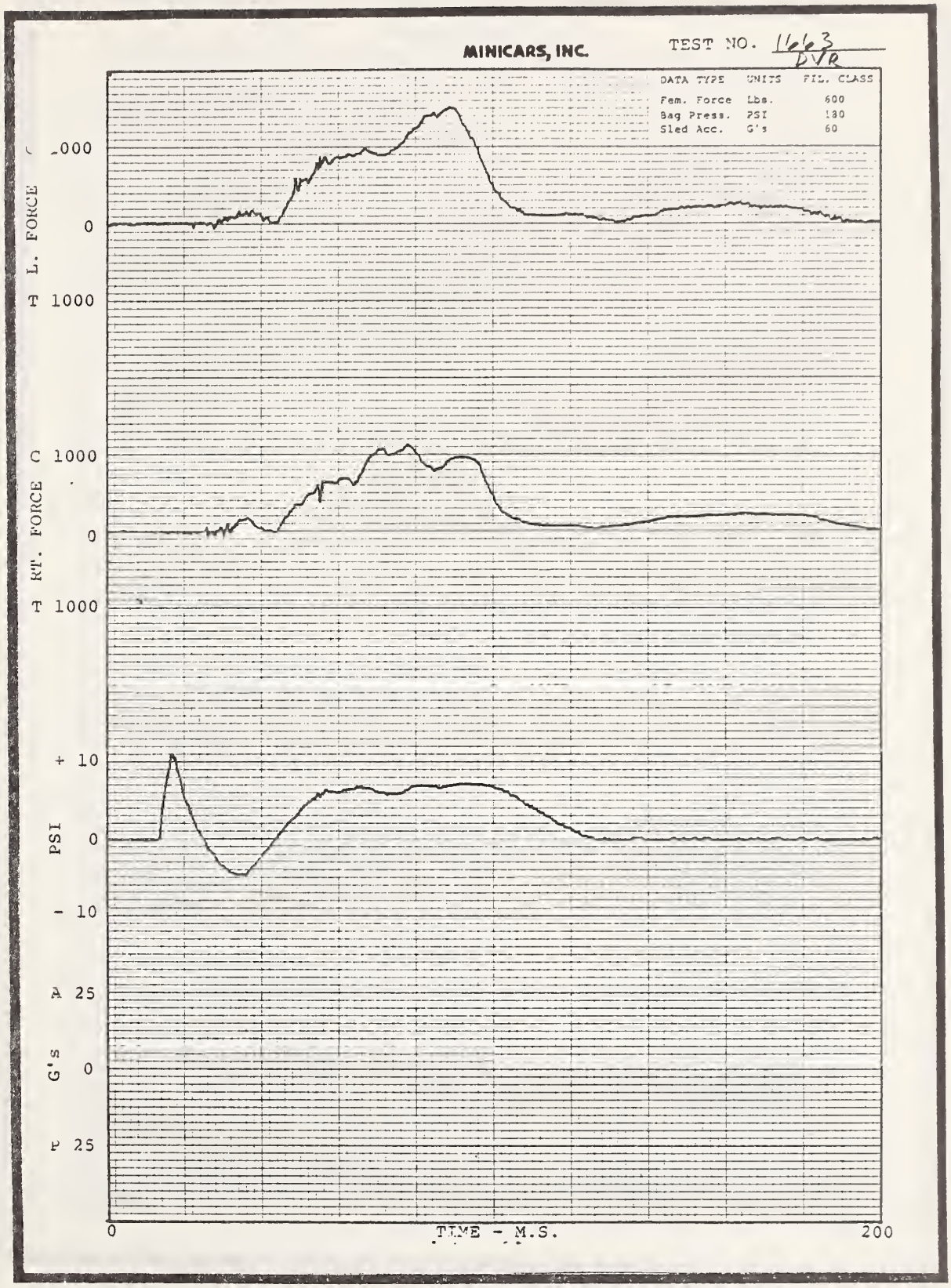

MINICARS, INC.
TEST NO. 1655
Pass
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 00
0
T 1000
L. FORCE
C 1000
0
T 1000
RT. FORCE
+ 10
PSI 0
- 10
A 25
G's 0
25
0
TIME - M.S.
200

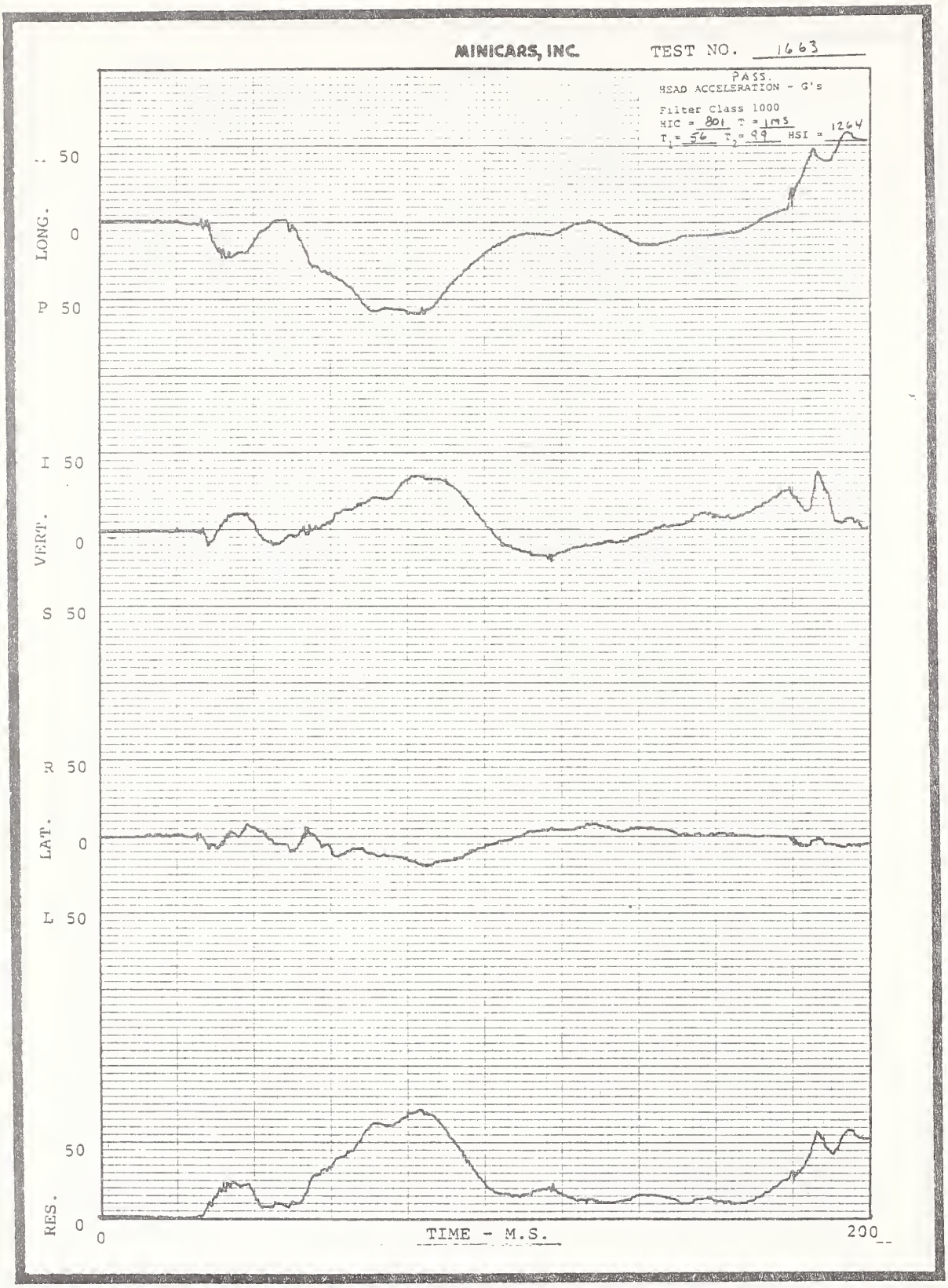

MINICARS, INC.
1655
SLED ACC G'S
1ST
2ND
FC 130
0
G'S
20
25
FPS
0
20
IN
0
TIME MS
200


MINICARS, INC.
SQUIB
0
TIME MS
200

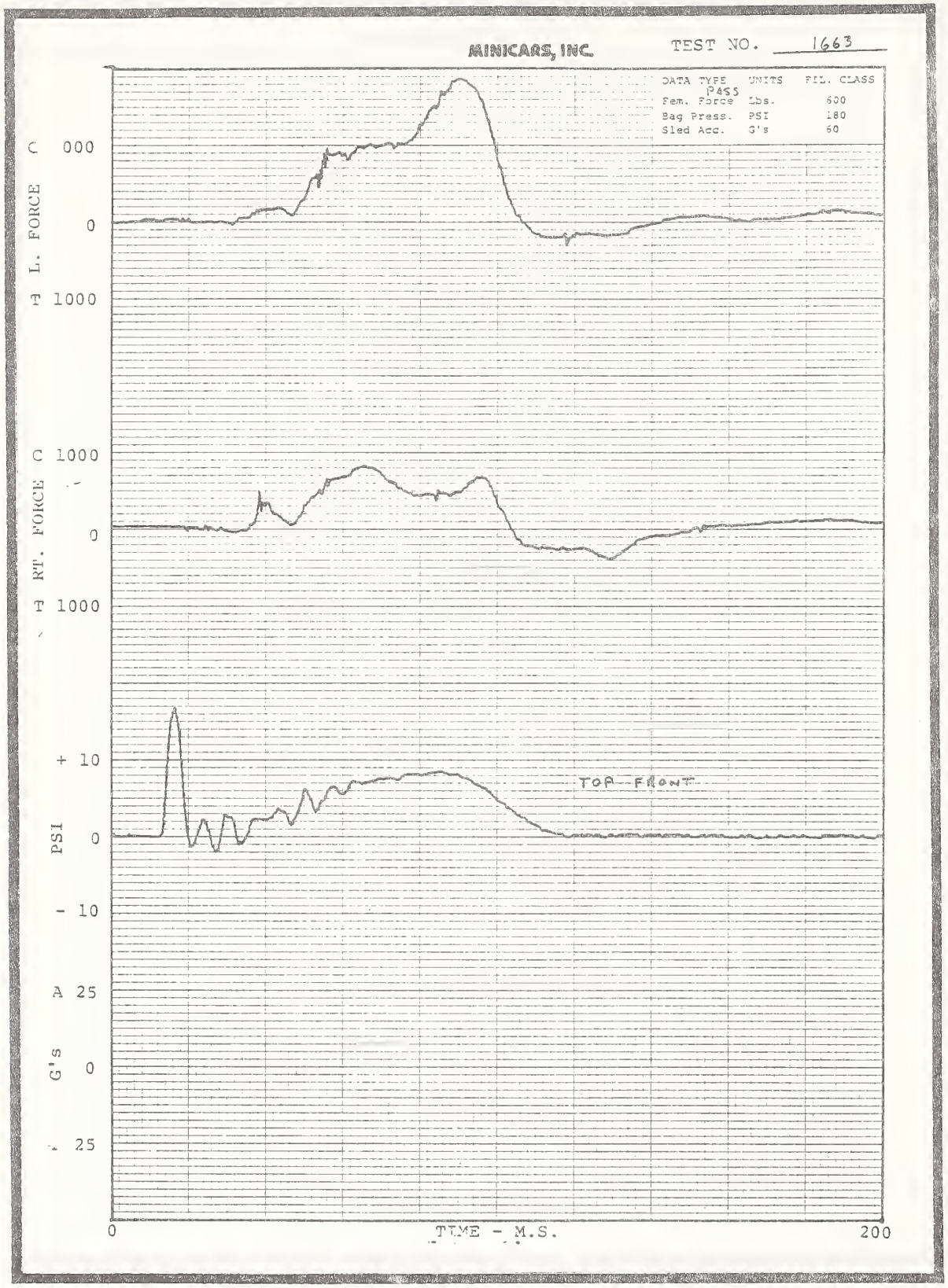

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
HSI =464
LONG.
VERT.
LAT.
RES.
50
0
P 50
I 50
S 50
R 50
L 50
0
200
TIME - M.S.

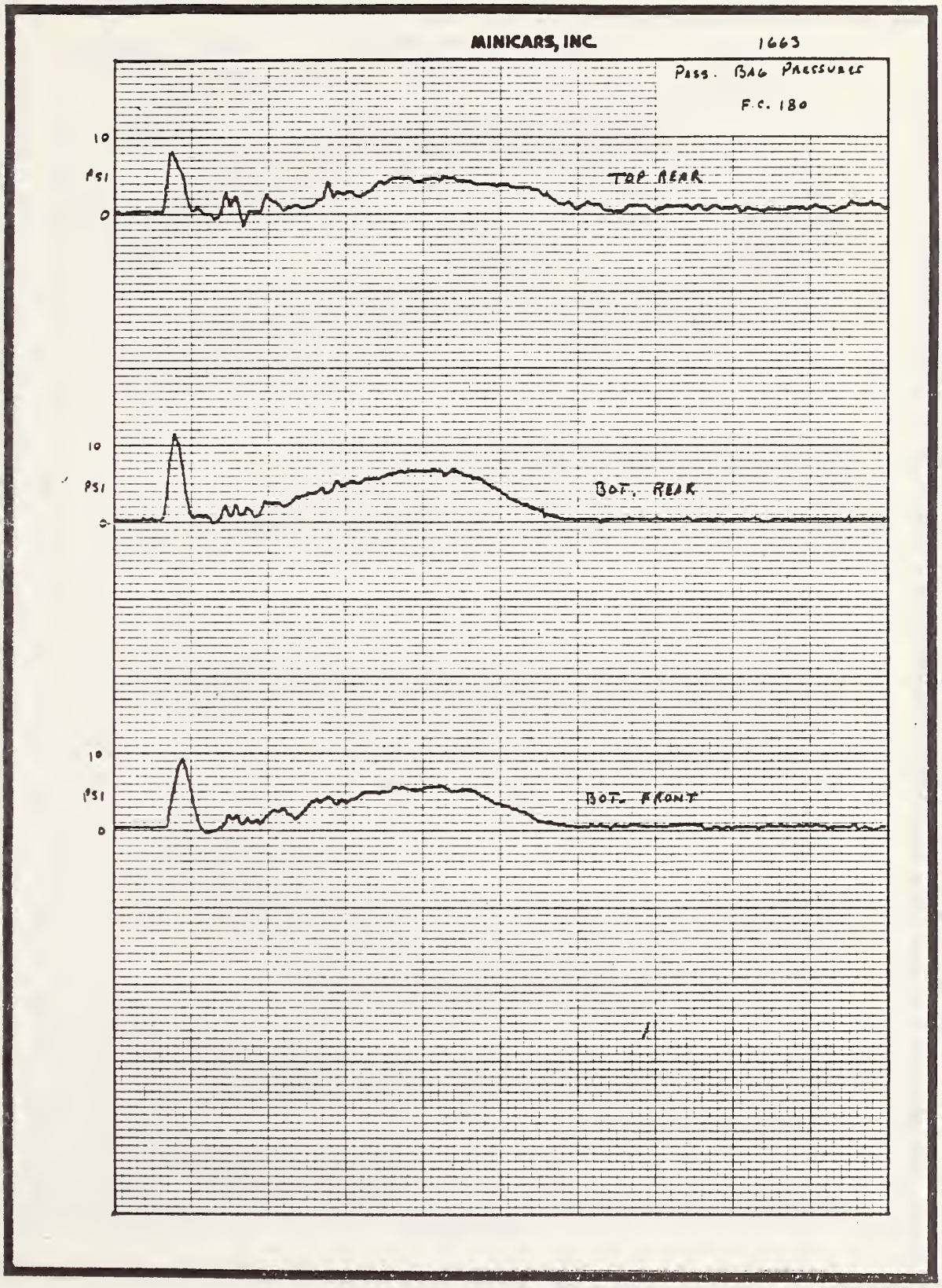

MINICARS, INC.
TEST NO. 1663
Chest Acceleration - G's
Filter Class 180
CSI = 643
DVR
LONG.
F 50
0
R 50
VERT.
H 50
0
S 50
LAT.
R 50
0
L 50
RES.
50
0
0
TIME - M.S.
200

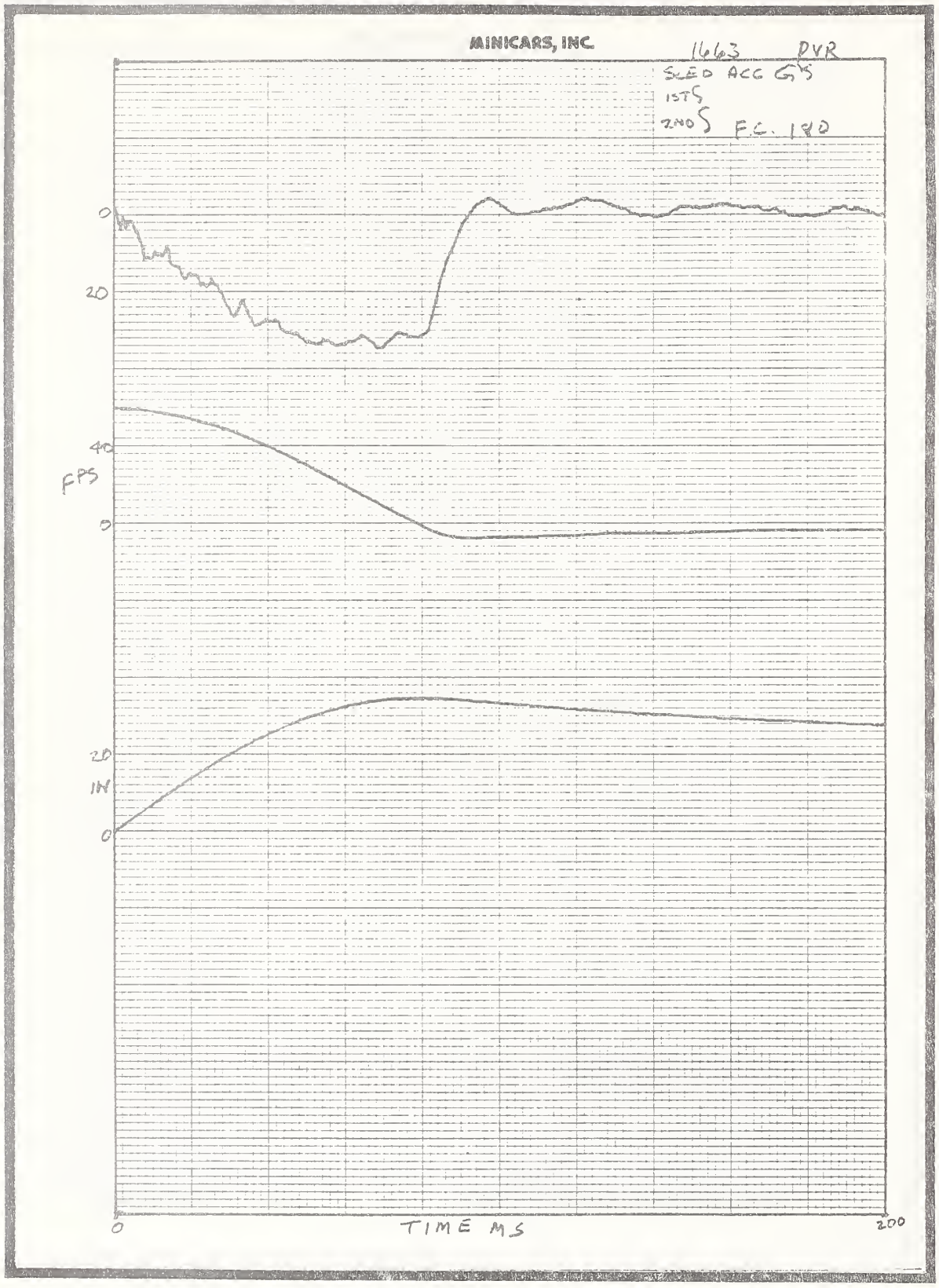

MINICARS, INC.
TEST NO. 1663 DVR
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
L. FORCE
1000
0
1000
RT. FORCE
1000
0
1000
PSI
+ 10
0
- 10
G's
25
0
25
0
TIME - M.S.
200

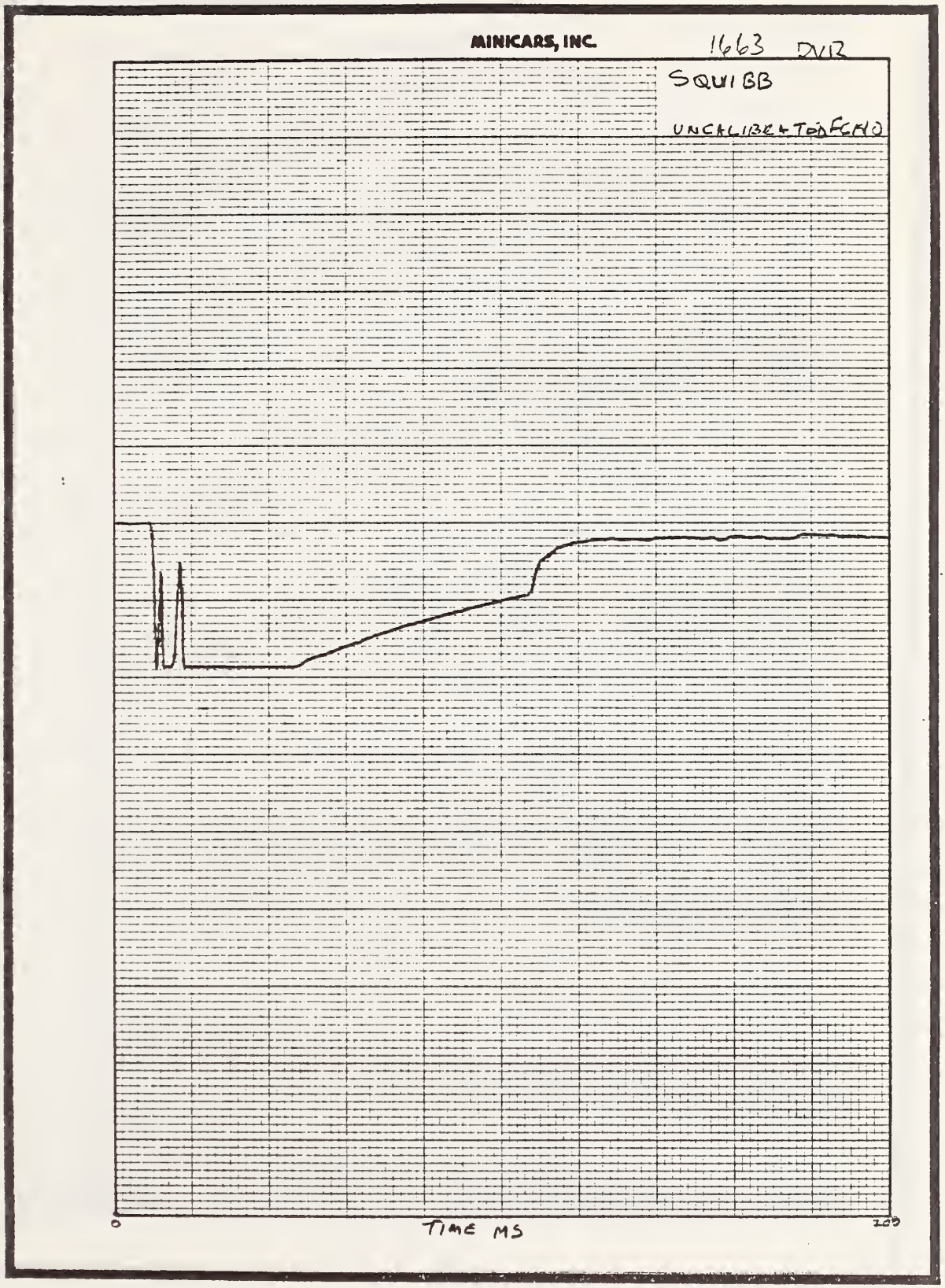

MINICARS, INC.
TEST NO. 1663
PASS.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 801 T = 1ms
T1 = 56 T2 = 99 HSI = 1264
50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

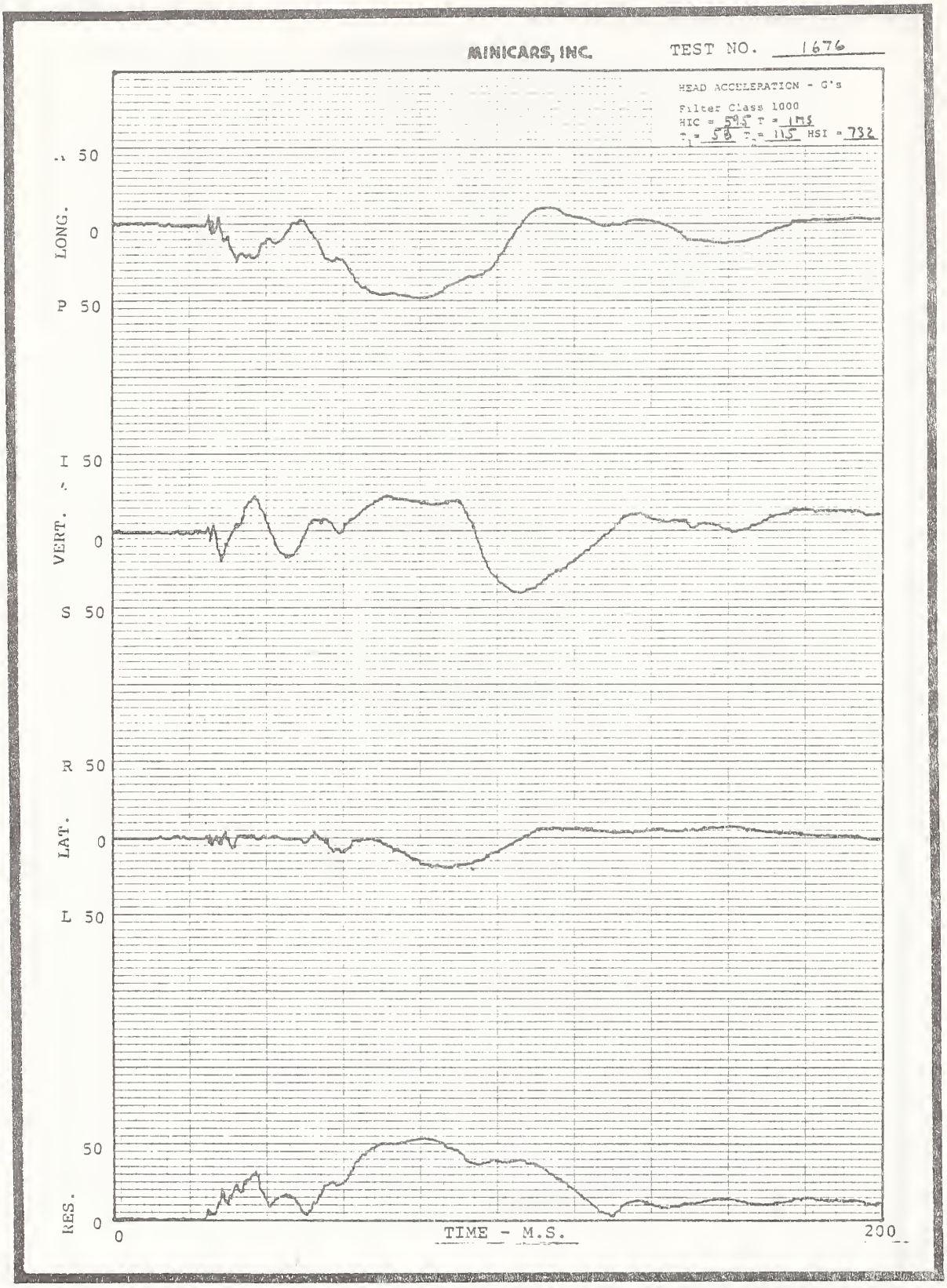
MINICARS, INC.
TEST NO. 1663
PASS.
Chest Acceleration - G's
Filter Class 180
CSI = 915
LONG.
VERT.
LAT.
RES.
50
0
TIME - M.S.
200

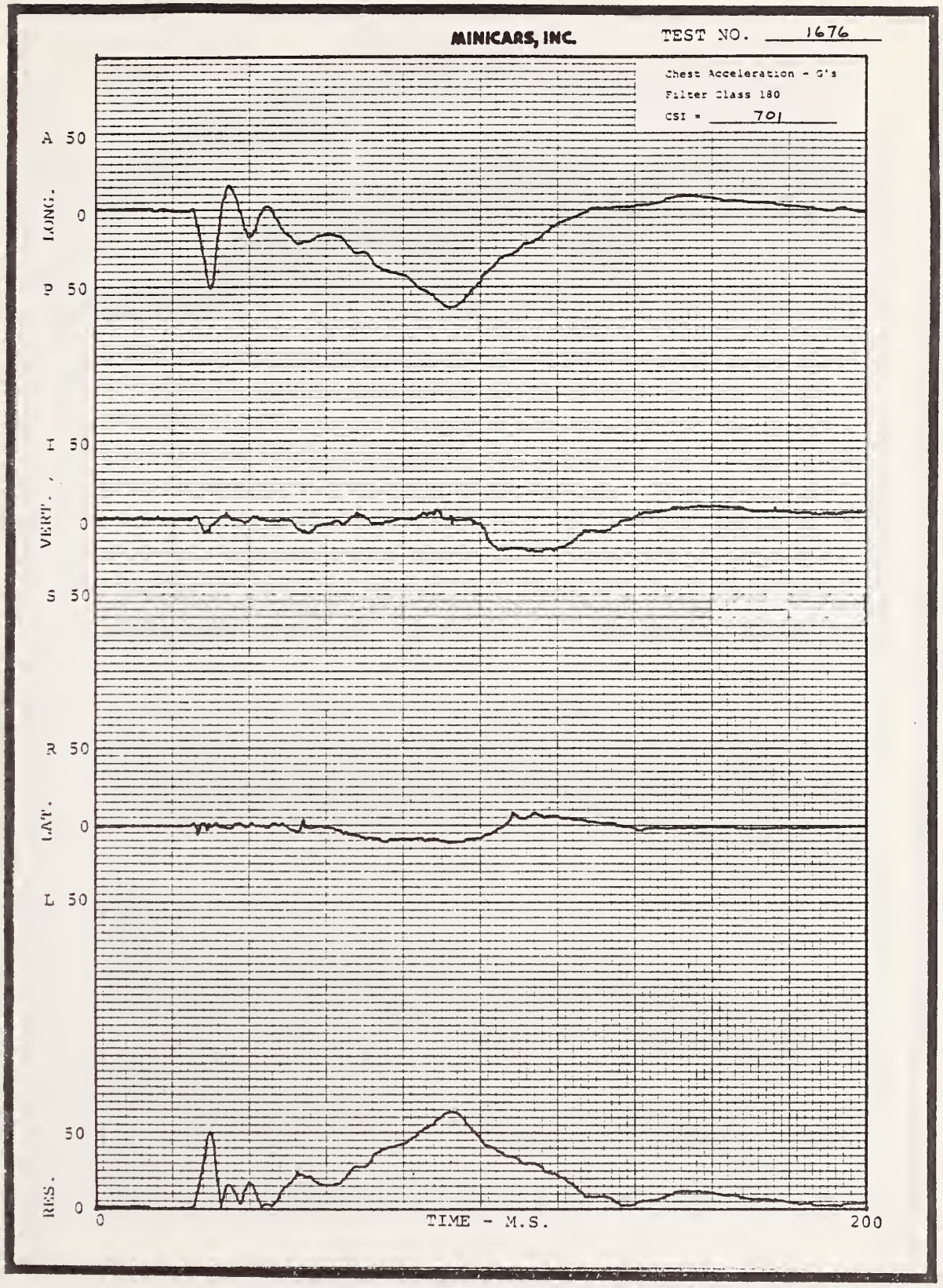

MINICARS, INC.
TEST NO. 1663
DATA TYPE UNITS FIL. CLASS
PASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
L. FORCE
000
0
1000
RT. FORCE
1000
0
1000
PSI
+ 10
0
- 10
G's
25
0
25
TOP FRONT
0
TIME - M.S.
200

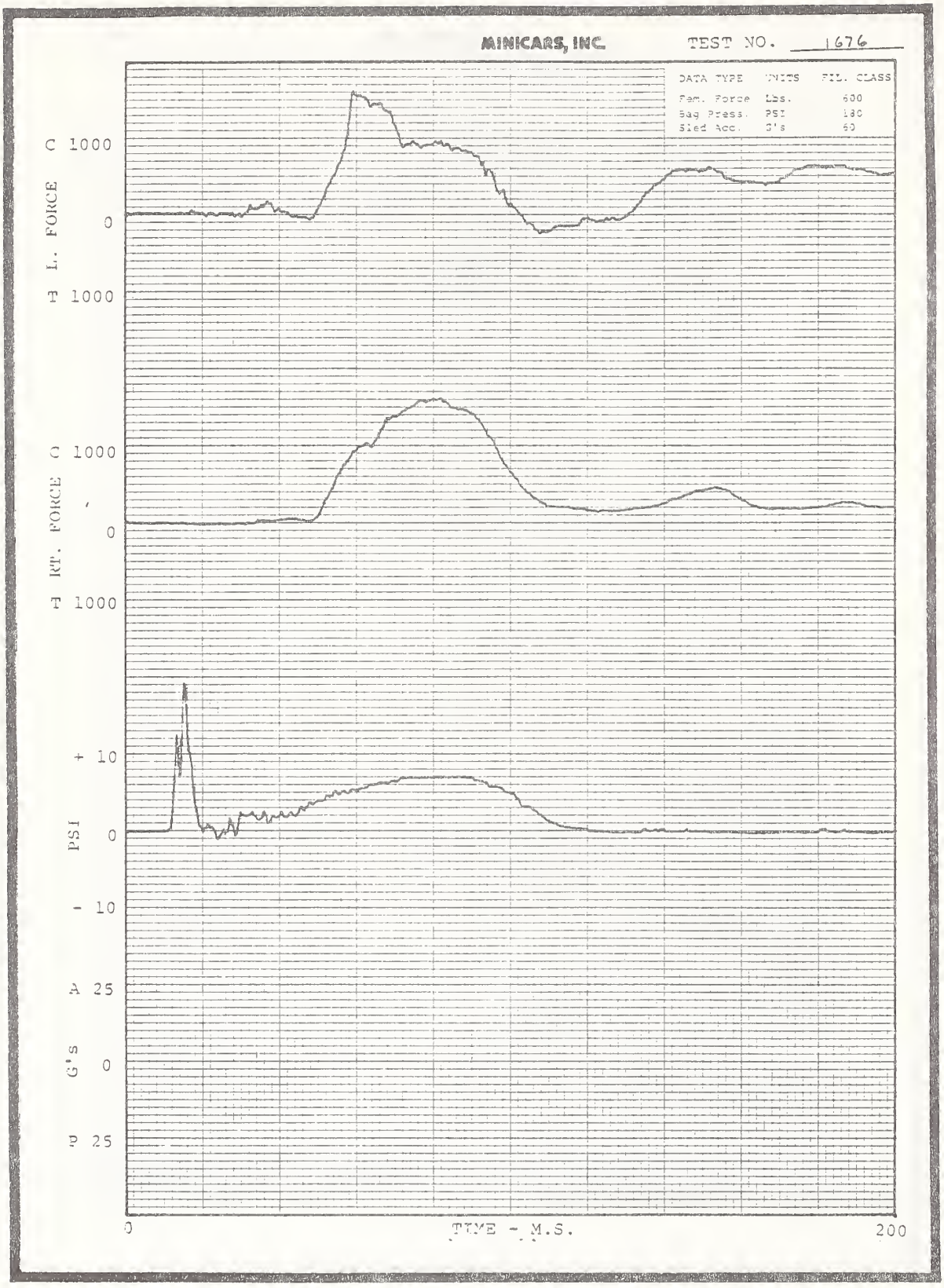

MINICARS, INC.
1663
PASS. BAG PRESSURES
F.C. 180
10
PSI
0
TOP REAR
10
PSI
0
BOT. REAR
10
PSI
0
BOT. FRONT

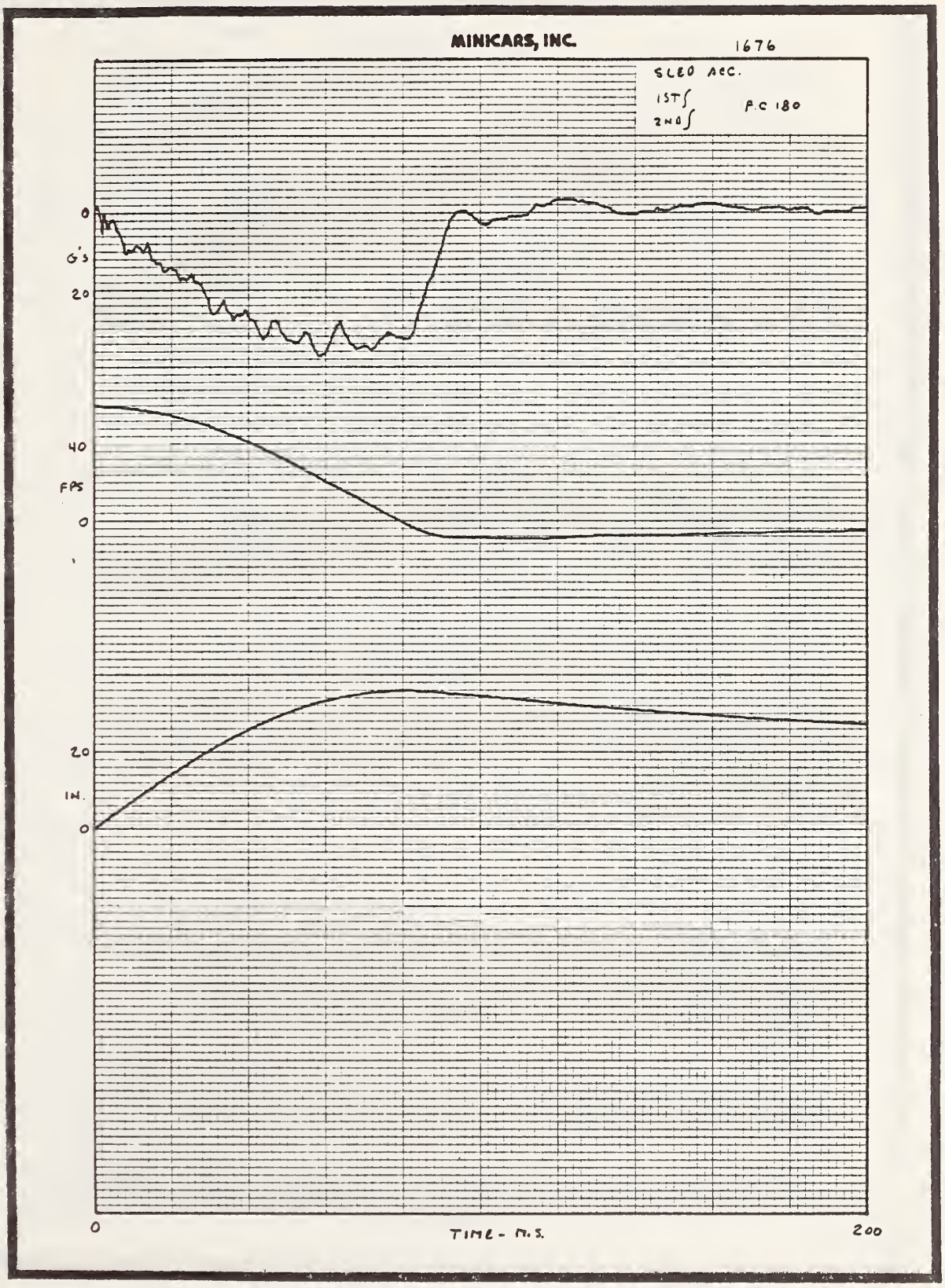

MINICARS, INC.
1663 DVR
SLED ACC G'S
1ST S
2ND S F.C. 180
0
20
40
FPS
0
20
IN
0
0
TIME MS
200

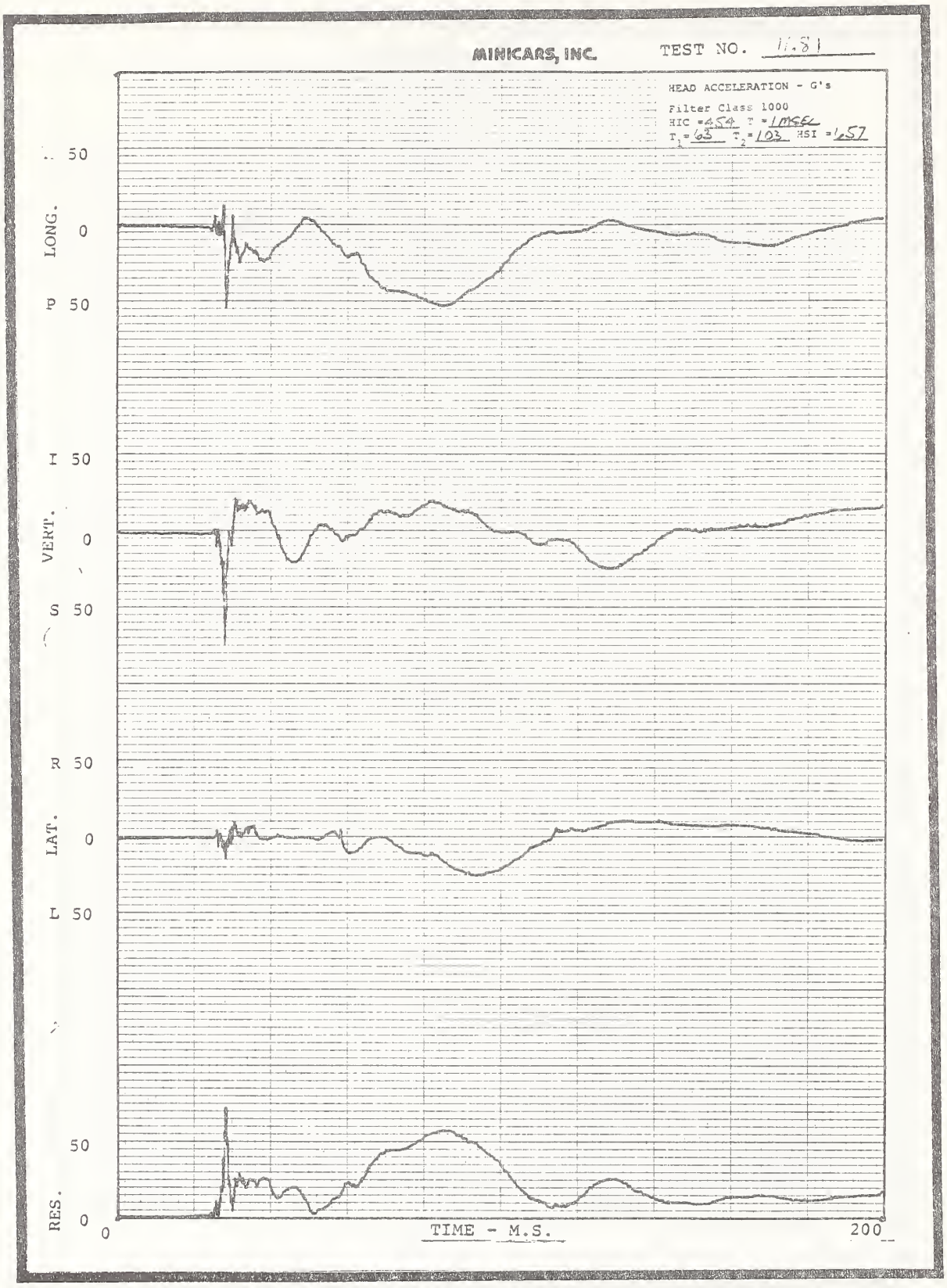

MINICARS, INC.
1663 DVR
SQUIBB
UNCALIBRATED FCMO
0
TIME MS
100

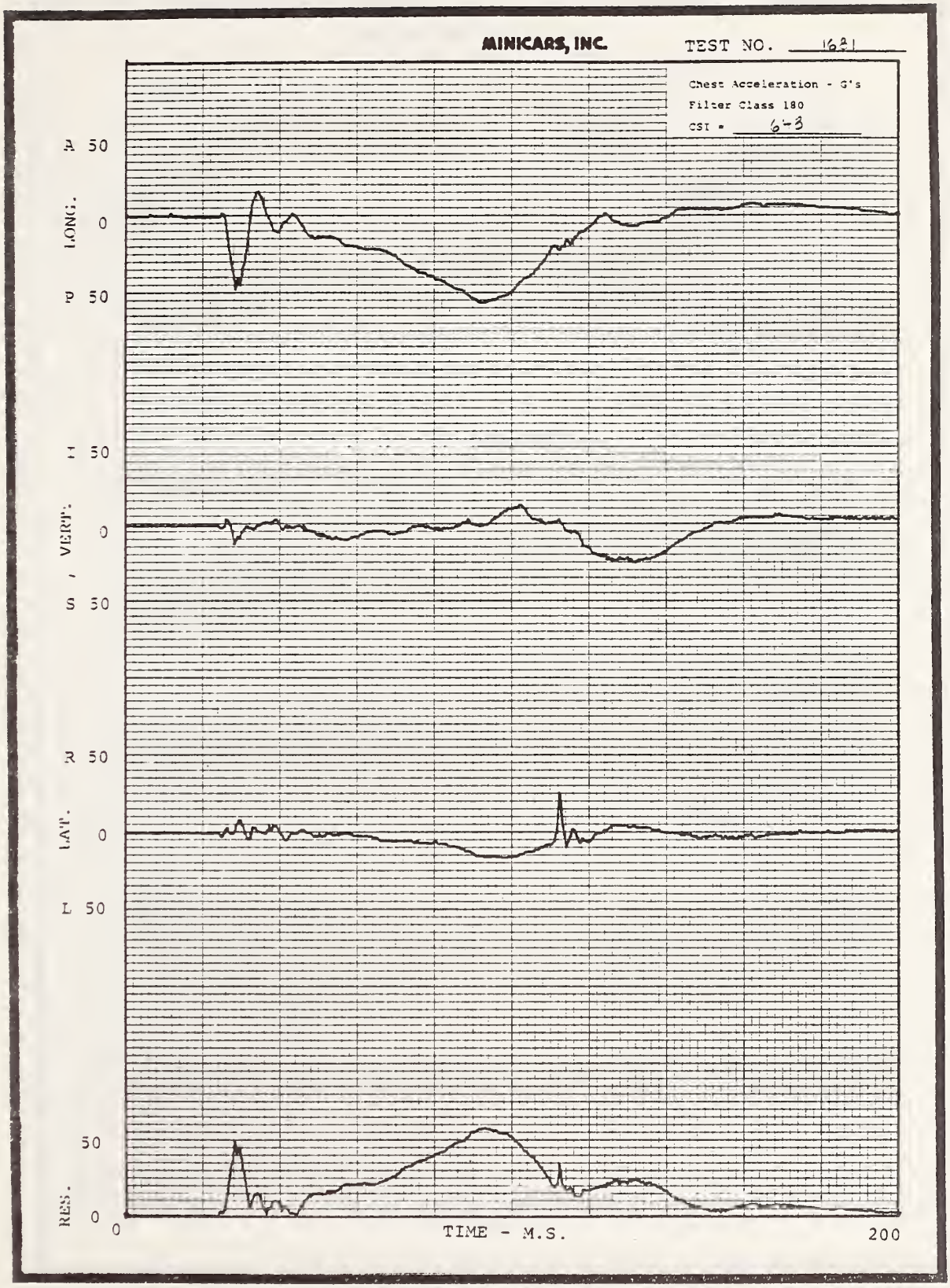

MINICARS, INC.
TEST NO. 1676
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 595 T = 1MS
T1 = 58 T2 = 115 HSI = 732
LONG.
P 50
0
VERT.
I 50
0
S 50
LAT.
R 50
0
L 50
RES.
50
0
0
TIME - M.S.
200

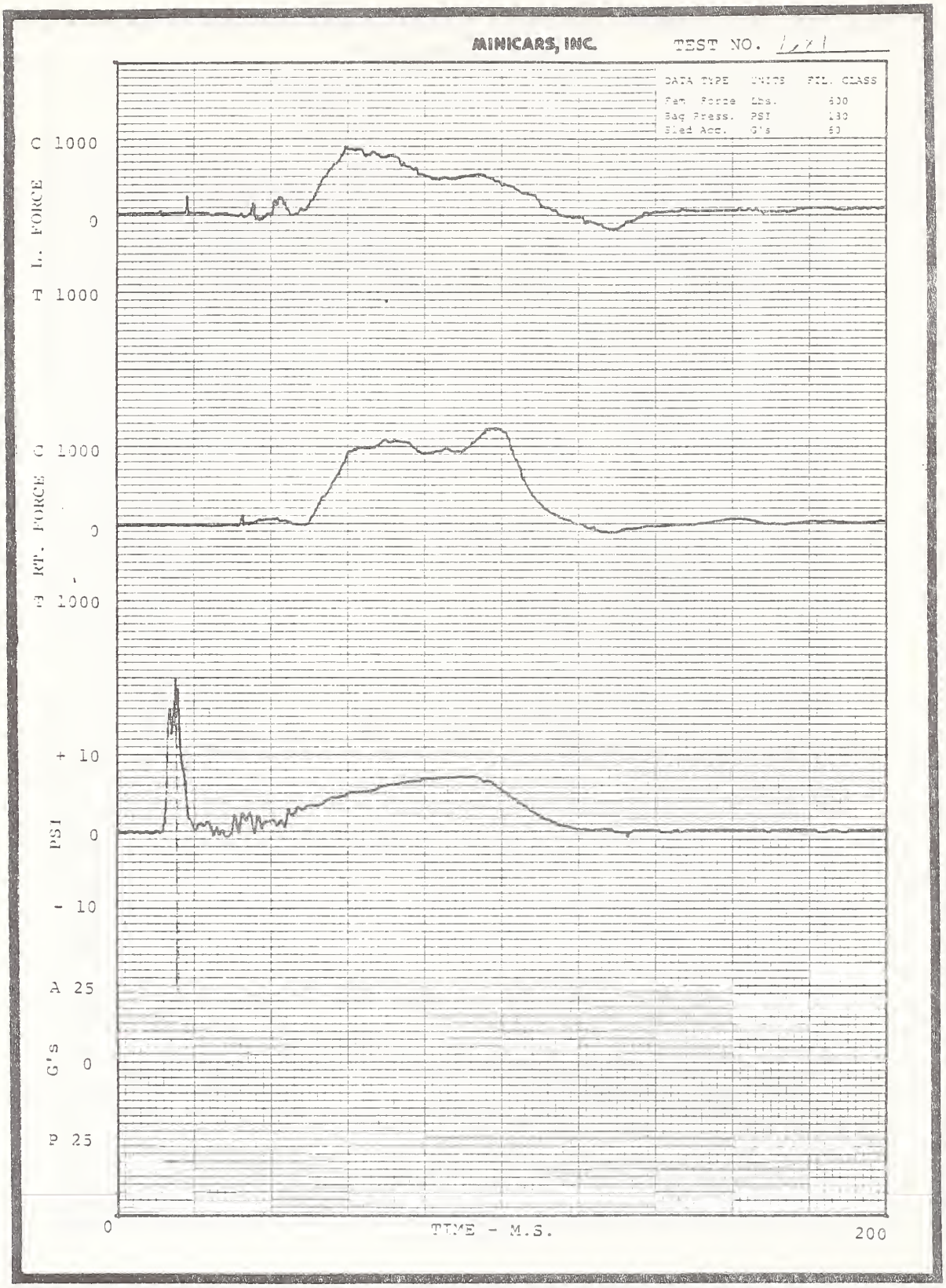

MINICARS, INC.
TEST NO. 1676
Chest Acceleration - G's
Filter Class 180
CSI = 701
A 50
LONG.
0
P 50
H 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

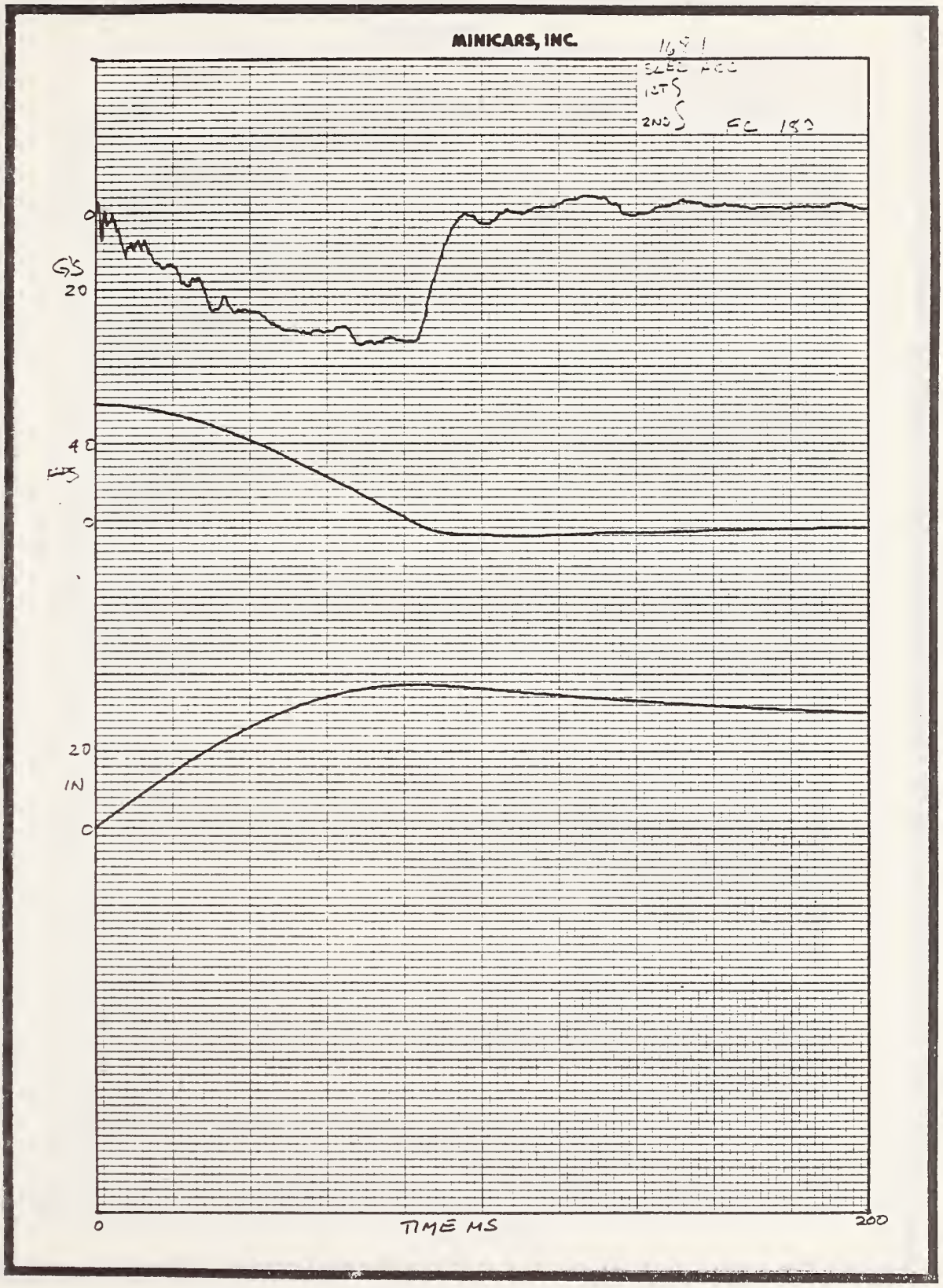

MINICARS, INC.
TEST NO. 1676
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
L. FORCE
0
T 1000
C 1000
RT. FORCE
0
T 1000
+ 10
PSI
0
- 10
A 25
G's
0
P 25
0
TIME - M.S.
200

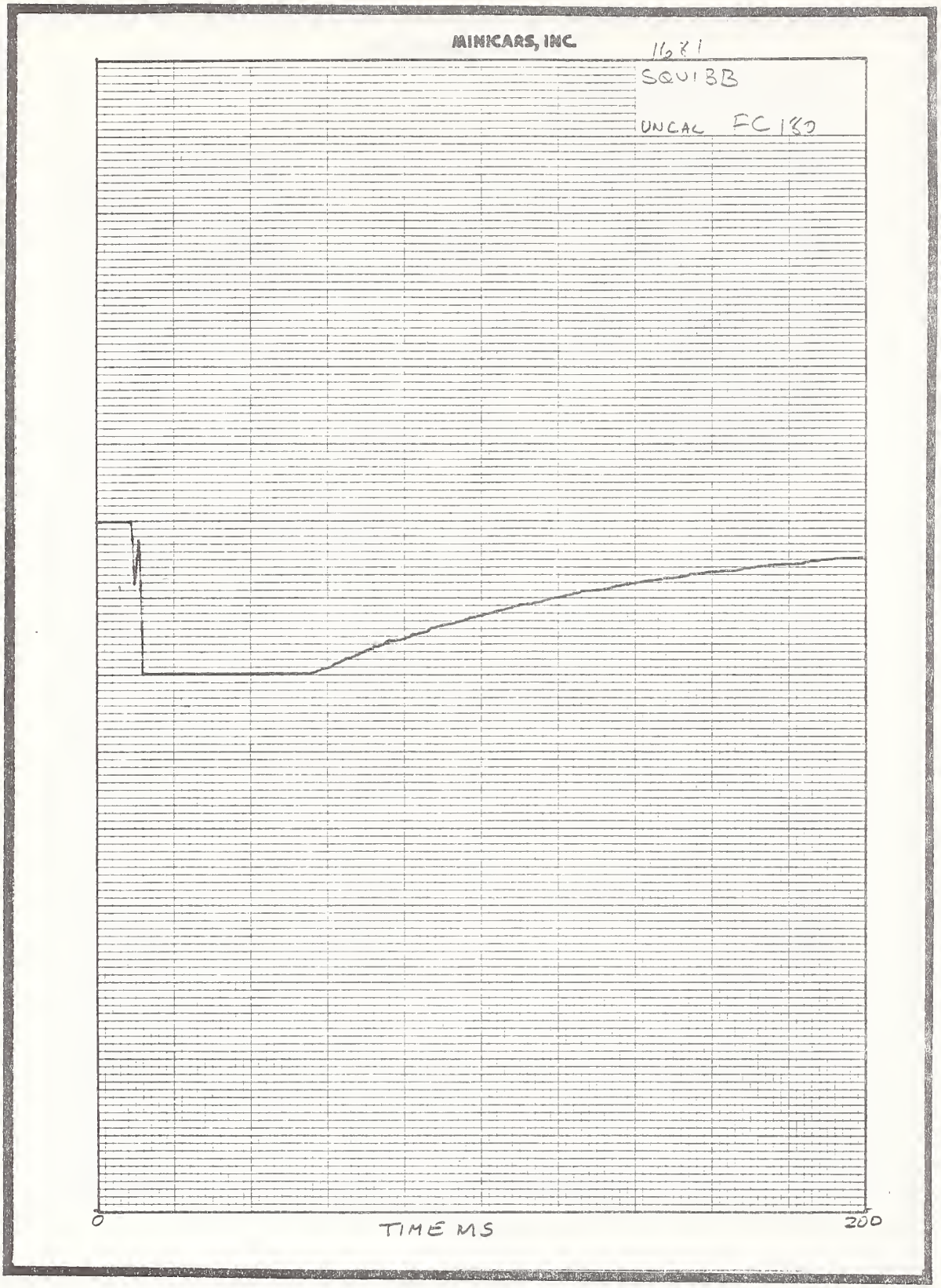

MINICARS, INC.
1676
SLED ACC.
1ST ∫
2ND ∫
P.C 180
0
G's
20
40
FPS
0
20
IN.
0
0
TIME - M.S.
200

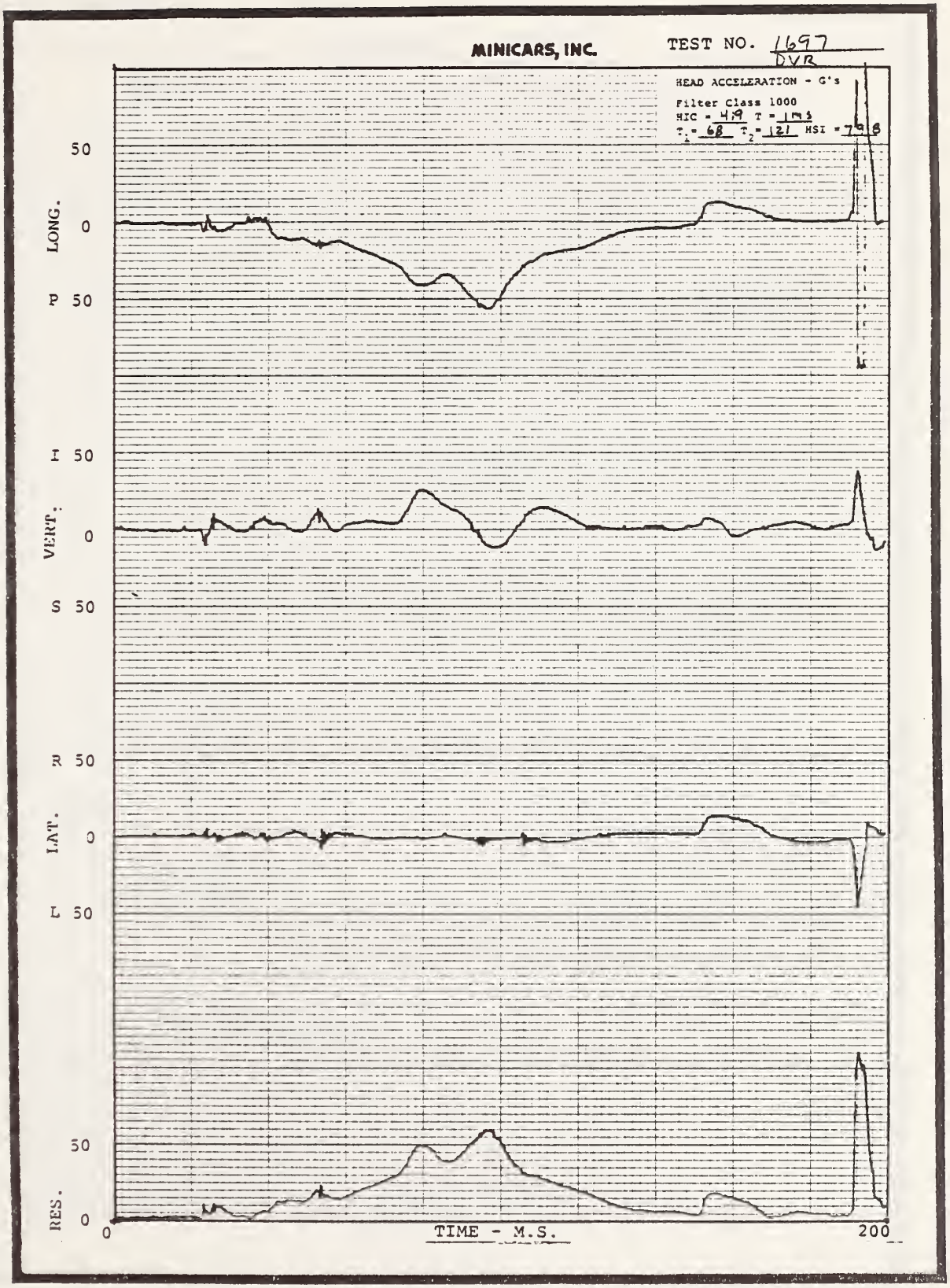

MINICARS, INC.
TEST NO. 11.81
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 454 T = 1.1 MSEC
T1 = 63 T2 = 103 HSI = 157
50
LONG.
0
50
50
VERT.
0
50
50
LAT.
0
50
50
RES.
0
0
TIME - M.S.
200

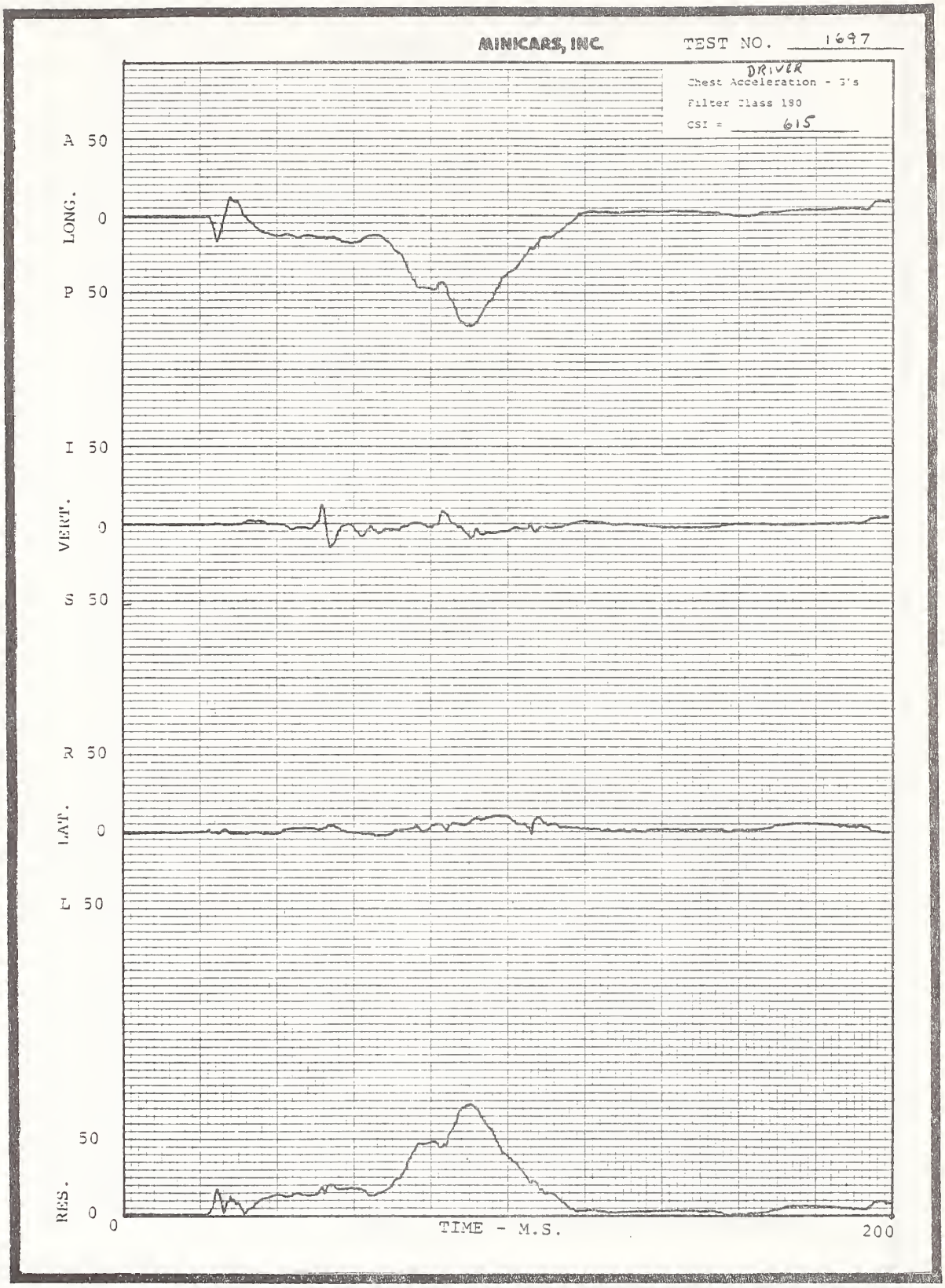

MINICARS, INC.
TEST NO. 1621
Chest Acceleration - G's
Filter Class 180
CSI = 6-3
A 50
LONG.
0
P 50
H 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

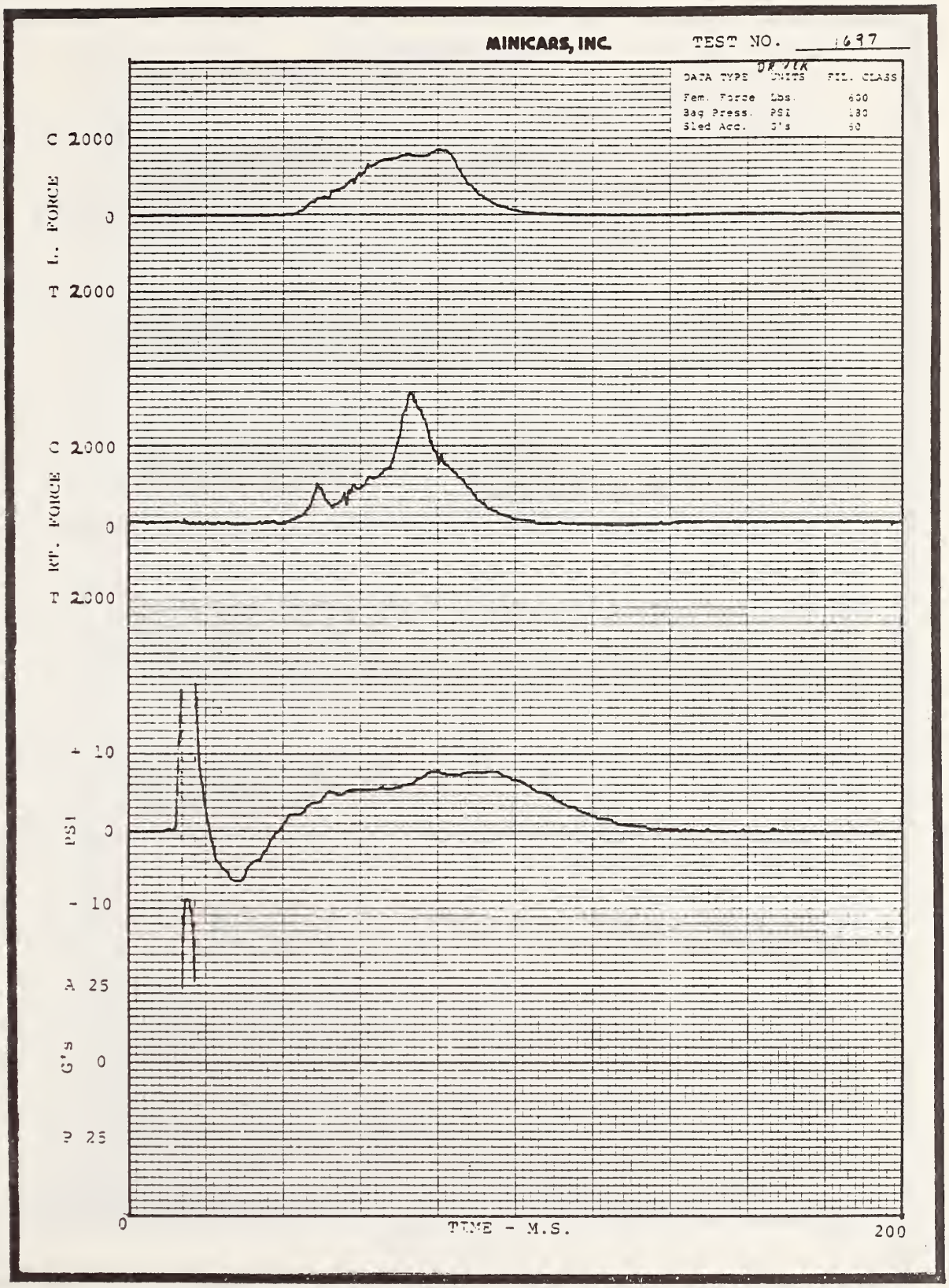

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem Force Lbs. 600
Bag Press. PSI 130
Sled Acc. G's 60
C 1000
L. FORCE
0
T 1000
C 1000
RT. FORCE
0
T 1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

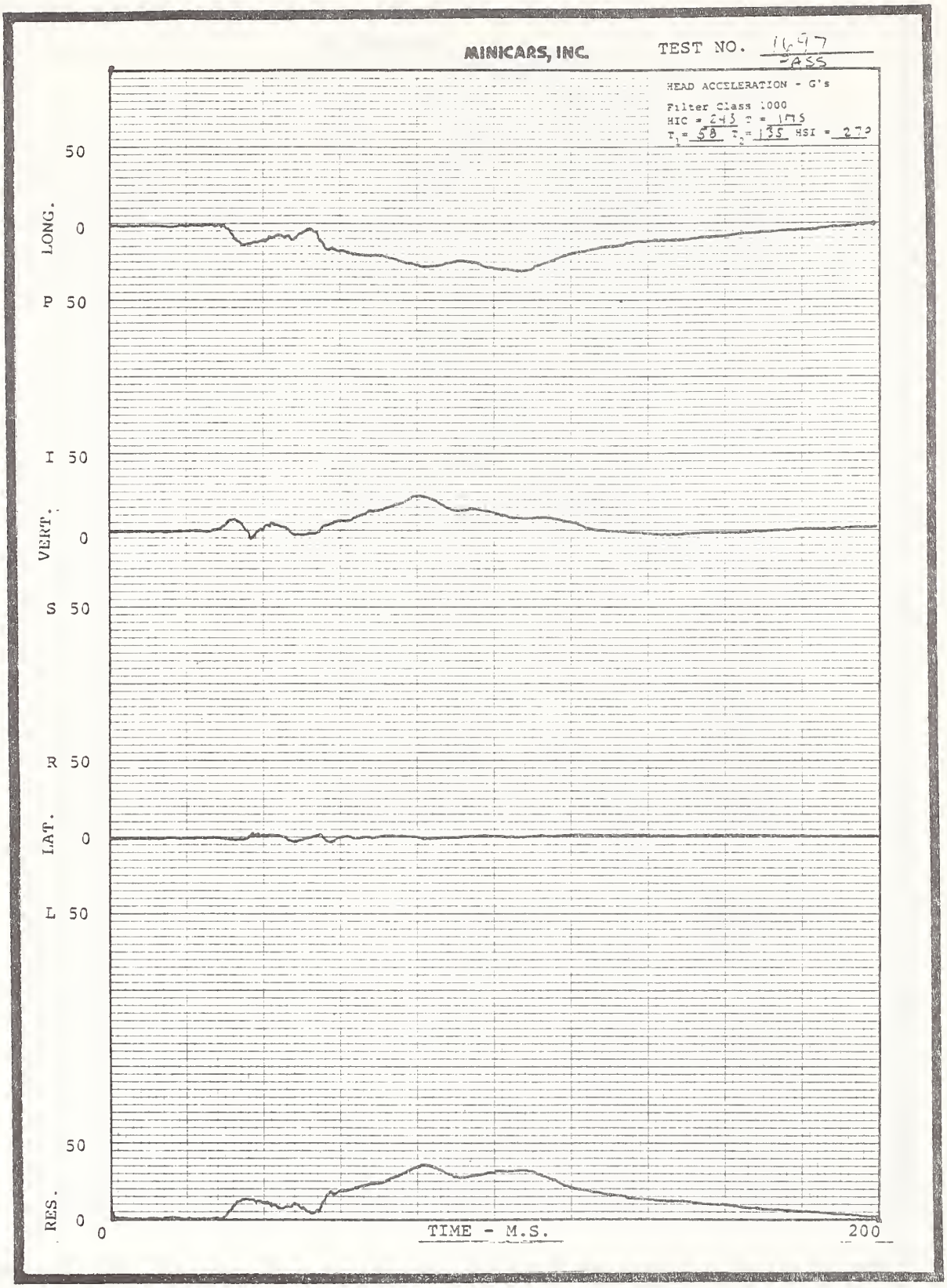

MINICARS, INC.
0
G'S
20
40
0
20
IN
0
0
TIME MS
200

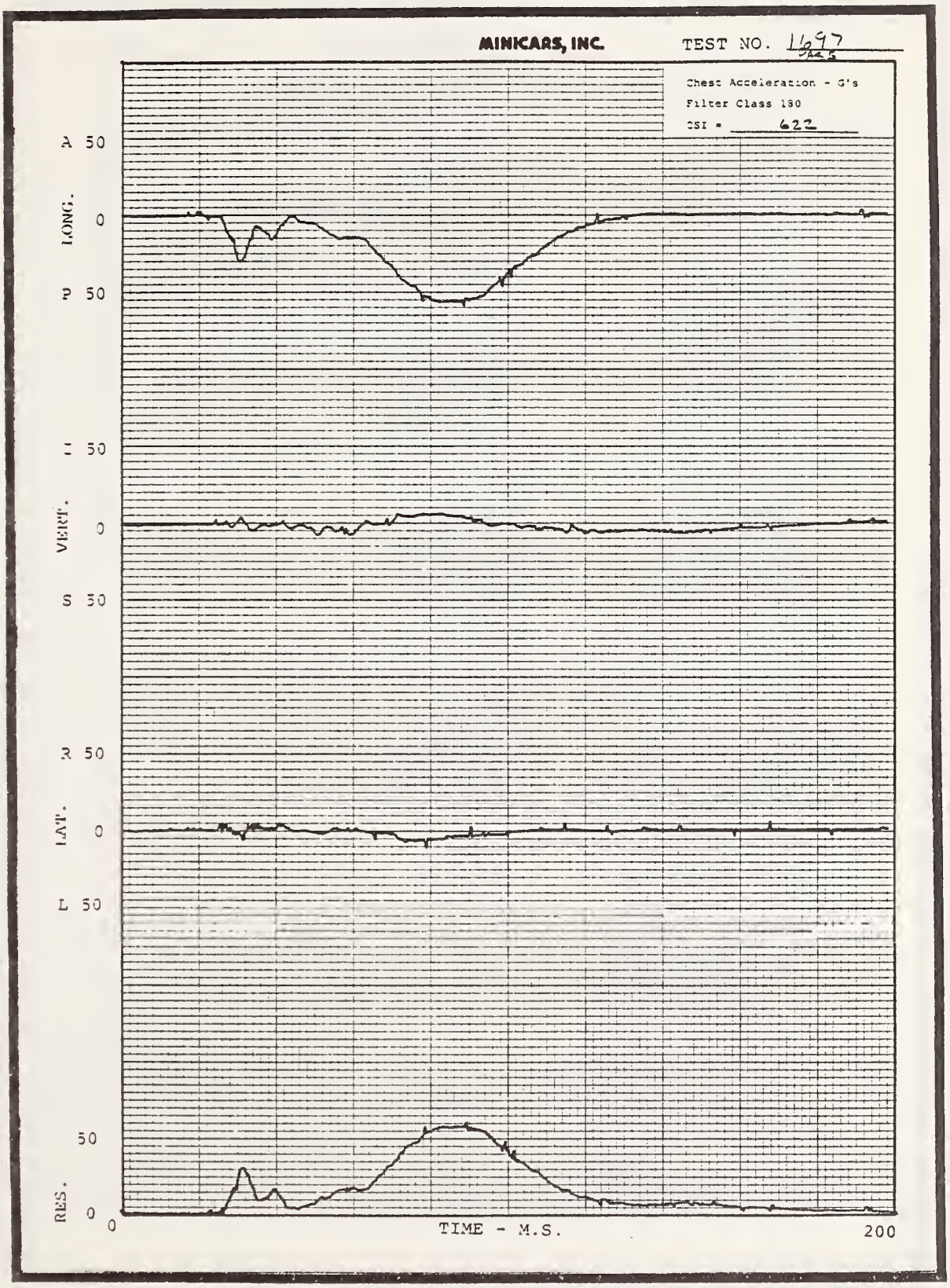

MINICARS, INC.
1681
SQUIBB
UNCAL FC 130
0
TIME MS
200

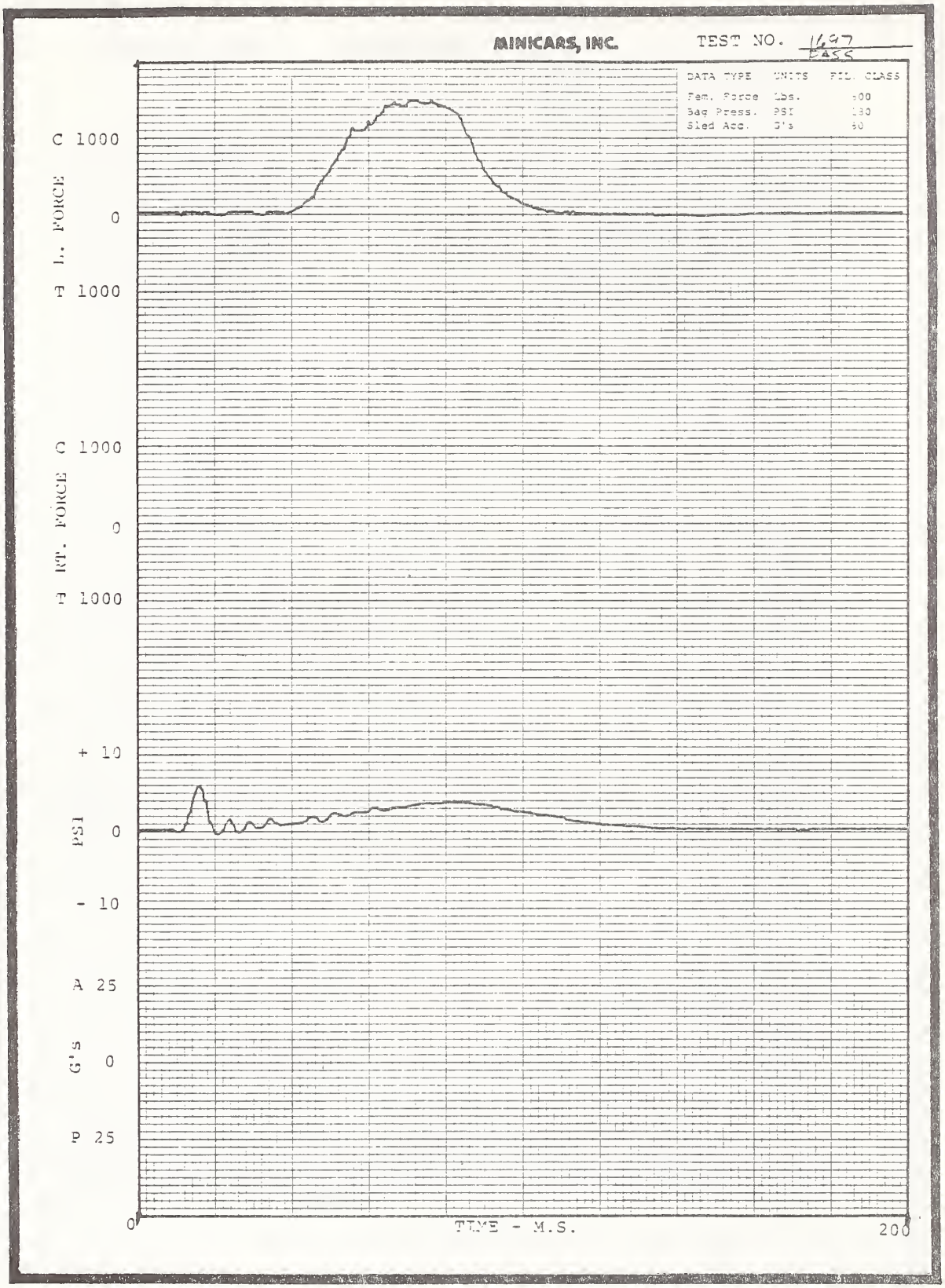

MINICARS, INC.
TEST NO. 1697 DVR
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 419 T = 1ms
T1 = 68 T2 = 121 HSI = 798
LONG.
P 50
0
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

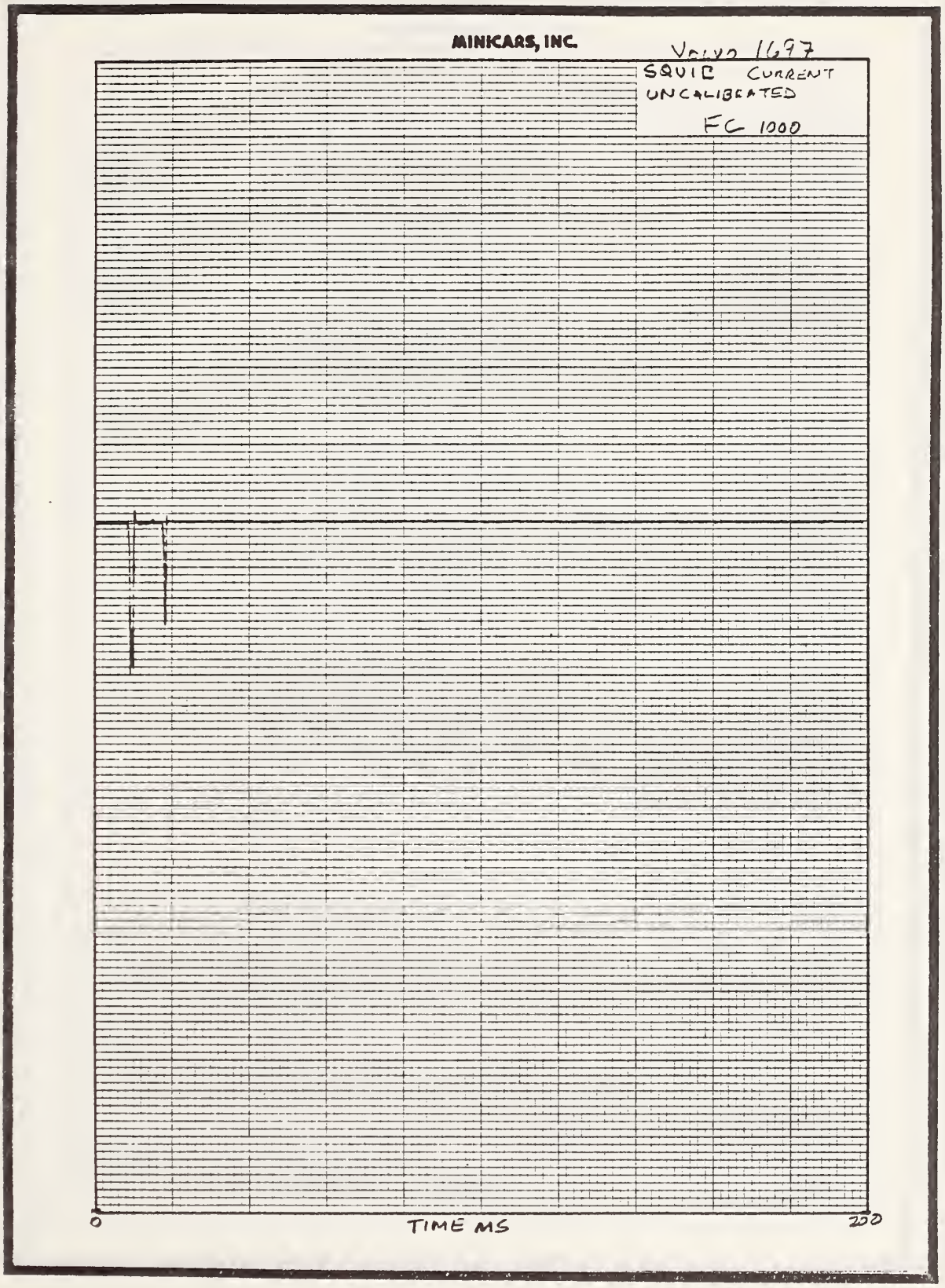

MINICARS, INC.
TEST NO. 1697
DRIVER
Chest Acceleration - G's
Filter Class 180
CSI = 615
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

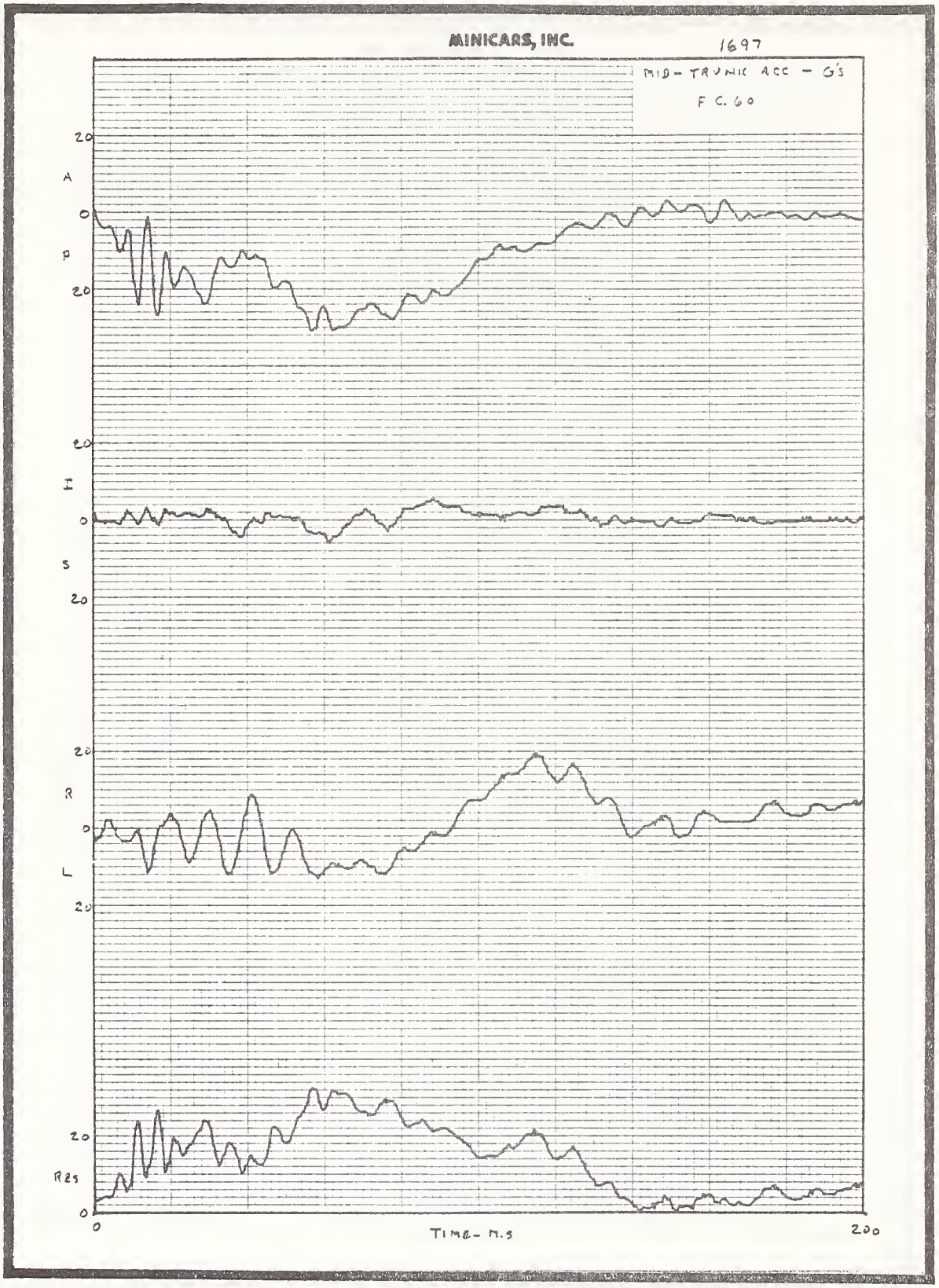

MINICARS, INC.
TEST NO. 1697
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 10
PSI
0
- 10
A 25
G's
0
P 25
0
TIME - M.S.
200

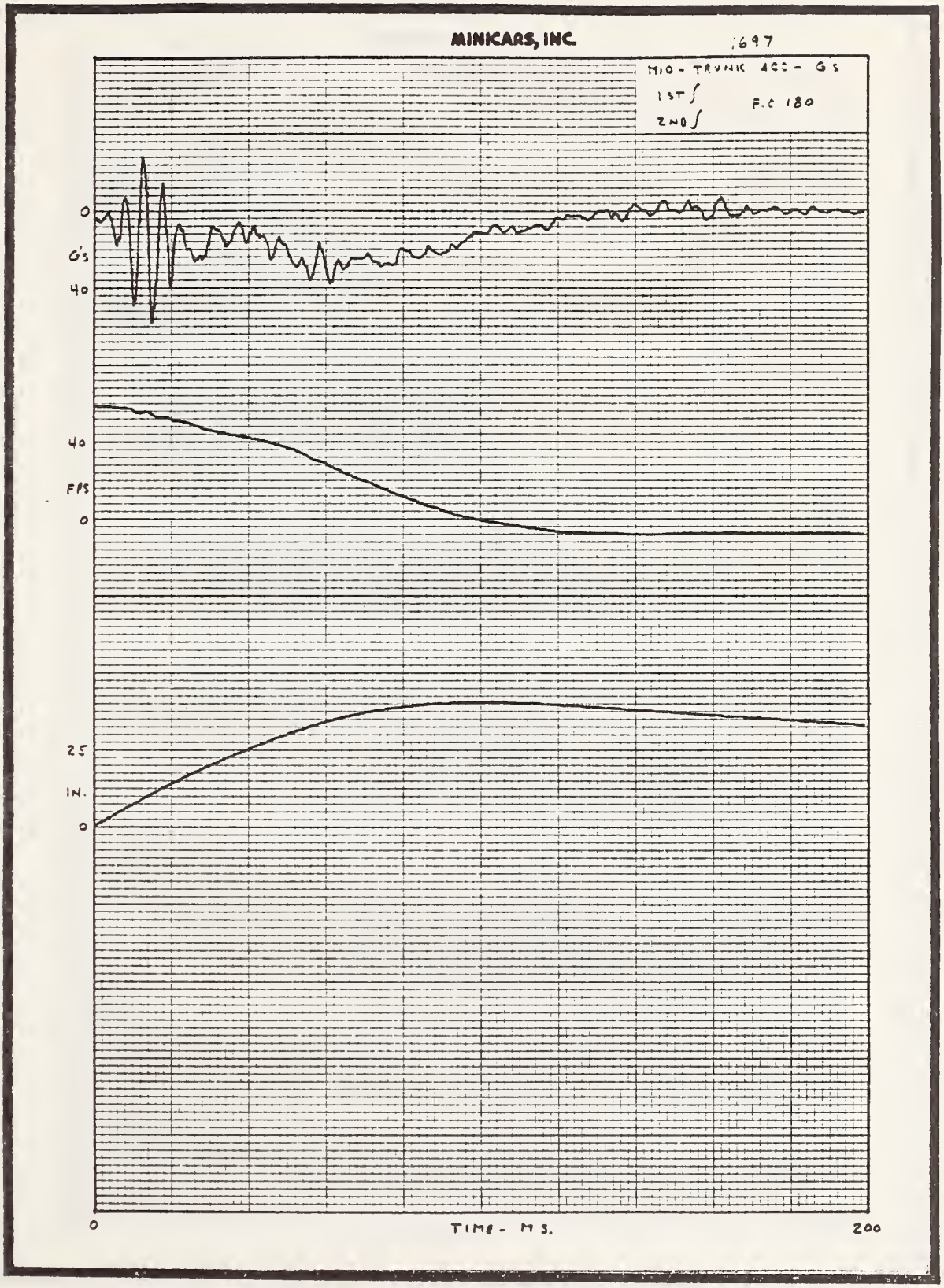

MINICARS, INC.
TEST NO. 1697 PASS
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 243 τ = 175
T1 = 58 T2 = 135 HSI = 279
LONG.
P 50
0
VERT.
I 50
0
S 50
LAT.
R 50
0
L 50
RES.
50
0
0
TIME - M.S.
200

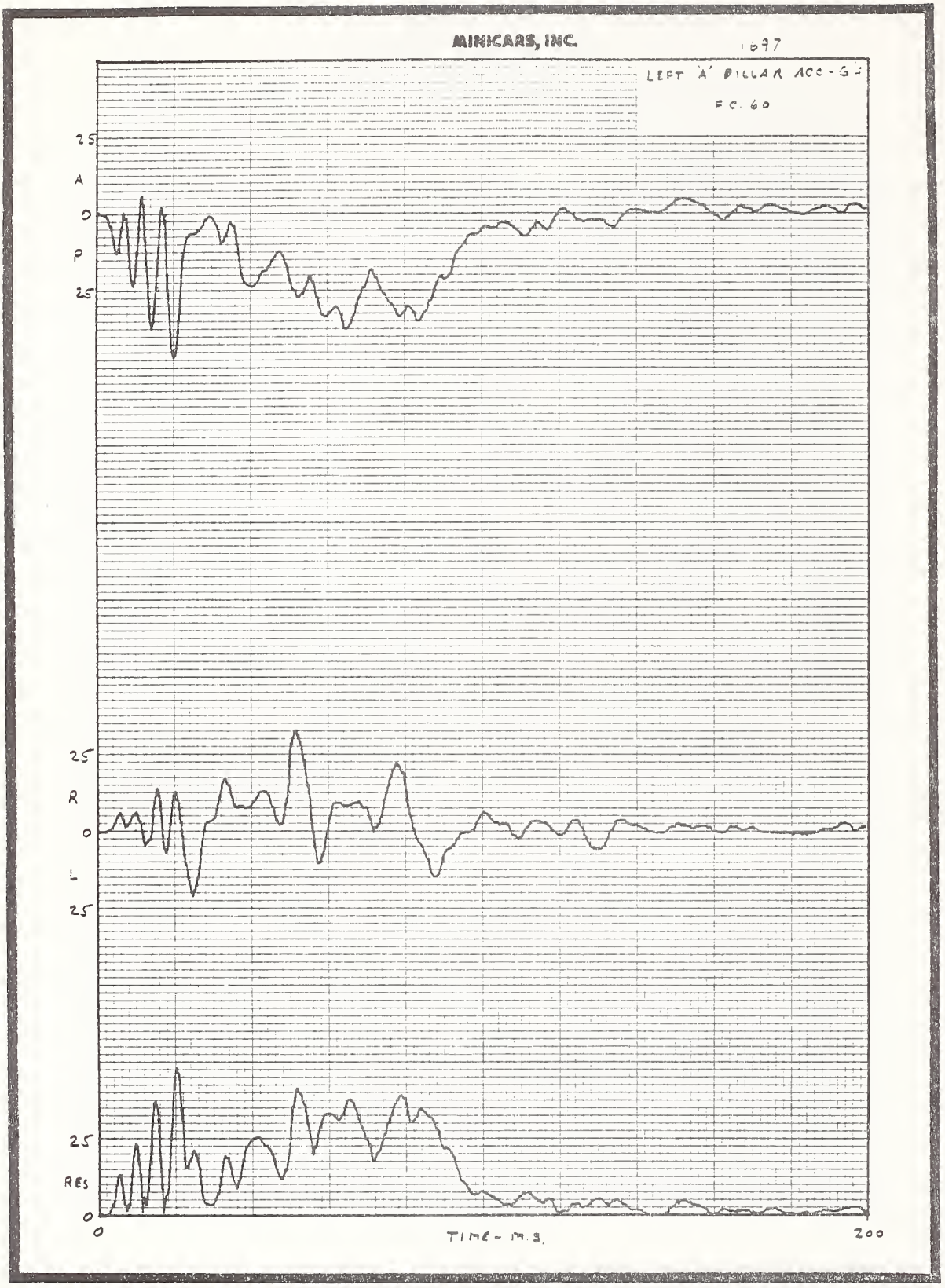

MINICARS, INC.
TEST NO. 1697
Chest Acceleration - G's
Filter Class 180
CSI = 622
A 50
LONG.
0
P 50
U 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

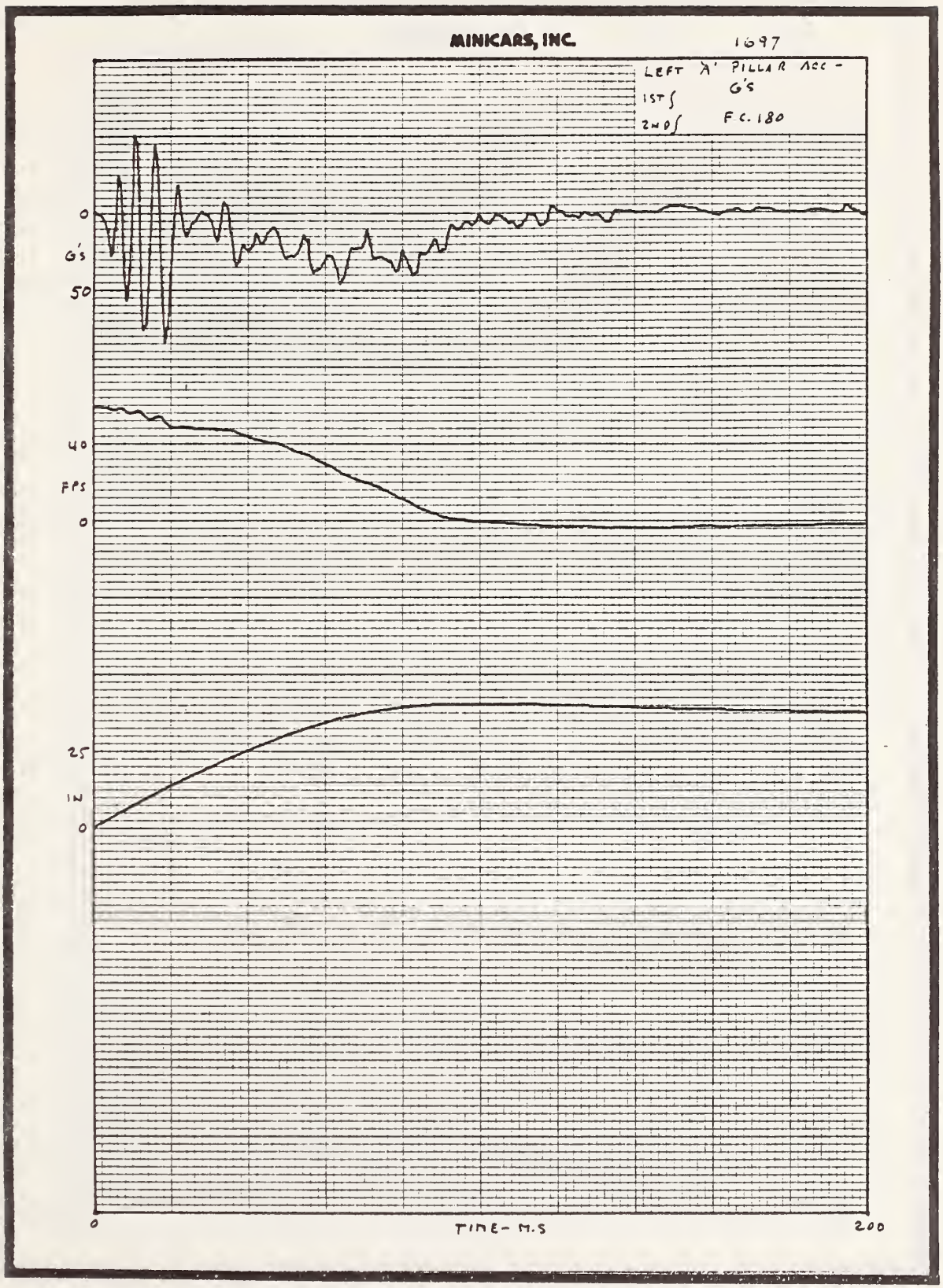

MINICARS, INC.
TEST NO. 1697
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
0
T 1000
FEM. FORCE
C 1000
0
T 1000
FEM. FORCE
+ 10
0
- 10
PSI
A 25
0
P 25
G's
0
TIME - M.S.
200

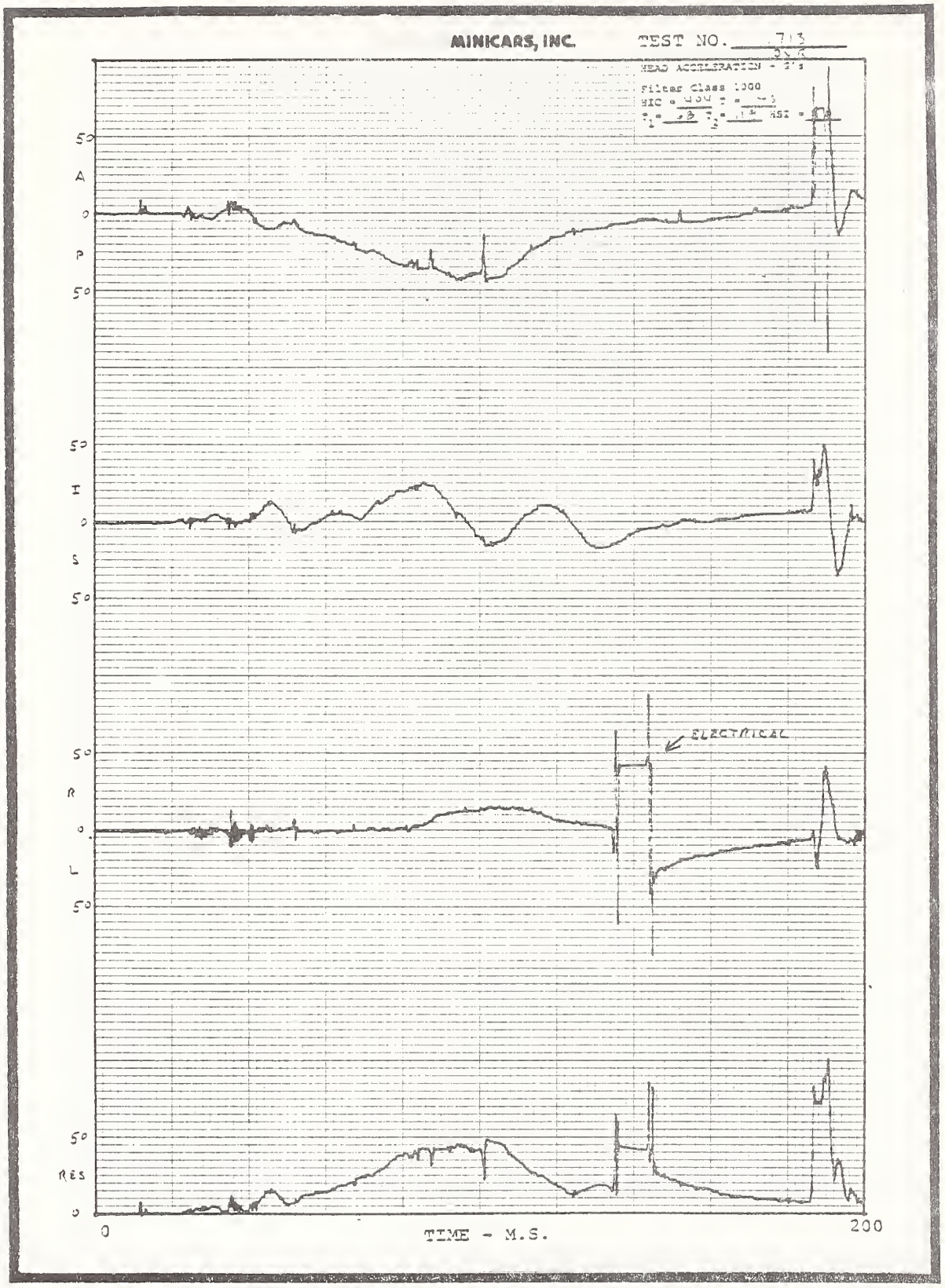

MINICARS, INC.
VOLVO 1697
SQUID CURRENT
UNCALIBRATED
FC 1000
0
TIME MS
200

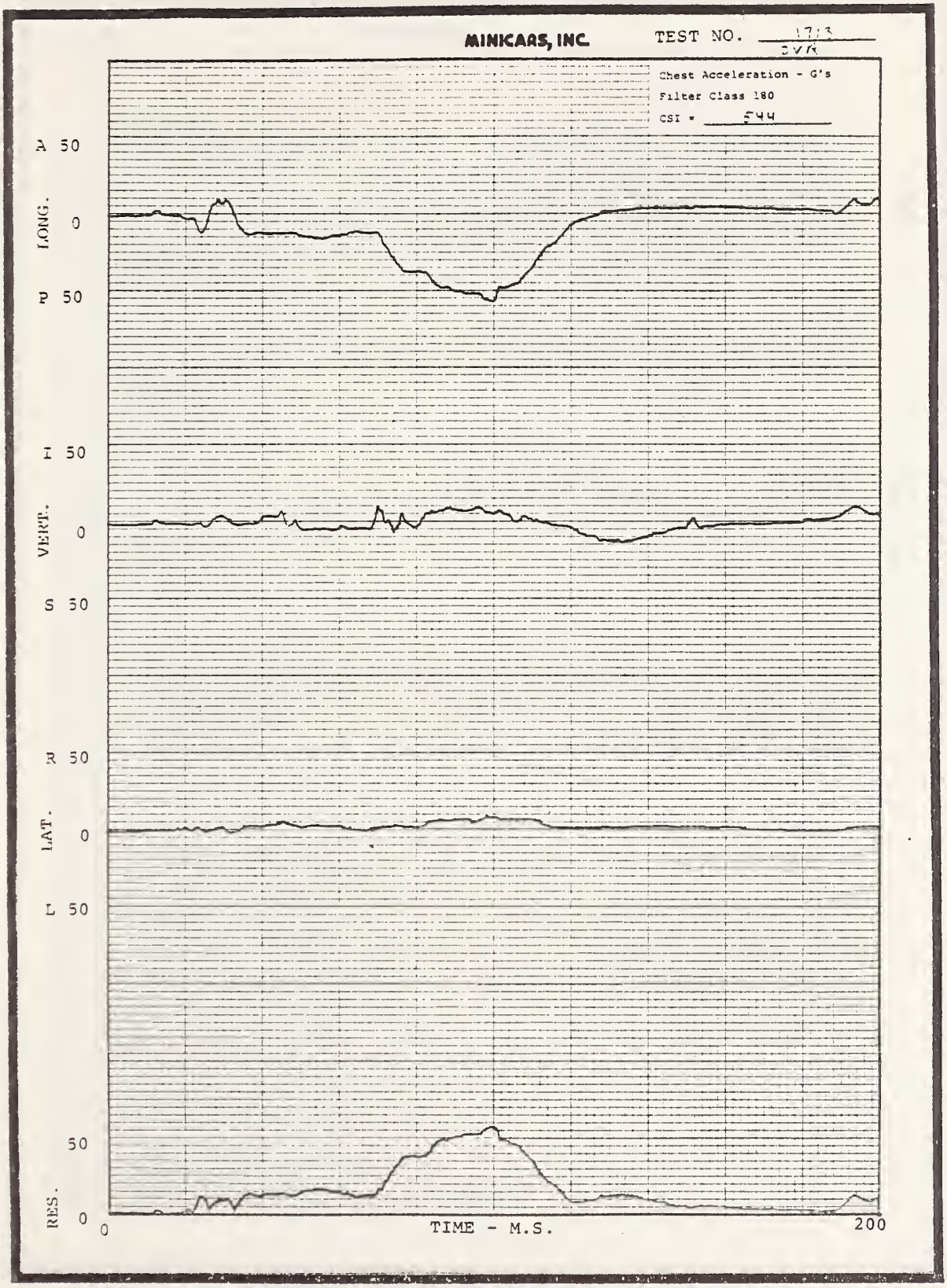

MINICARS, INC.
1697
MID-TRUNK ACC - G'S
F C. 60
20
A
0
P
20
20
H
0
S
20
20
R
0
L
20
20
RES
0
0
TIME- M.S
200

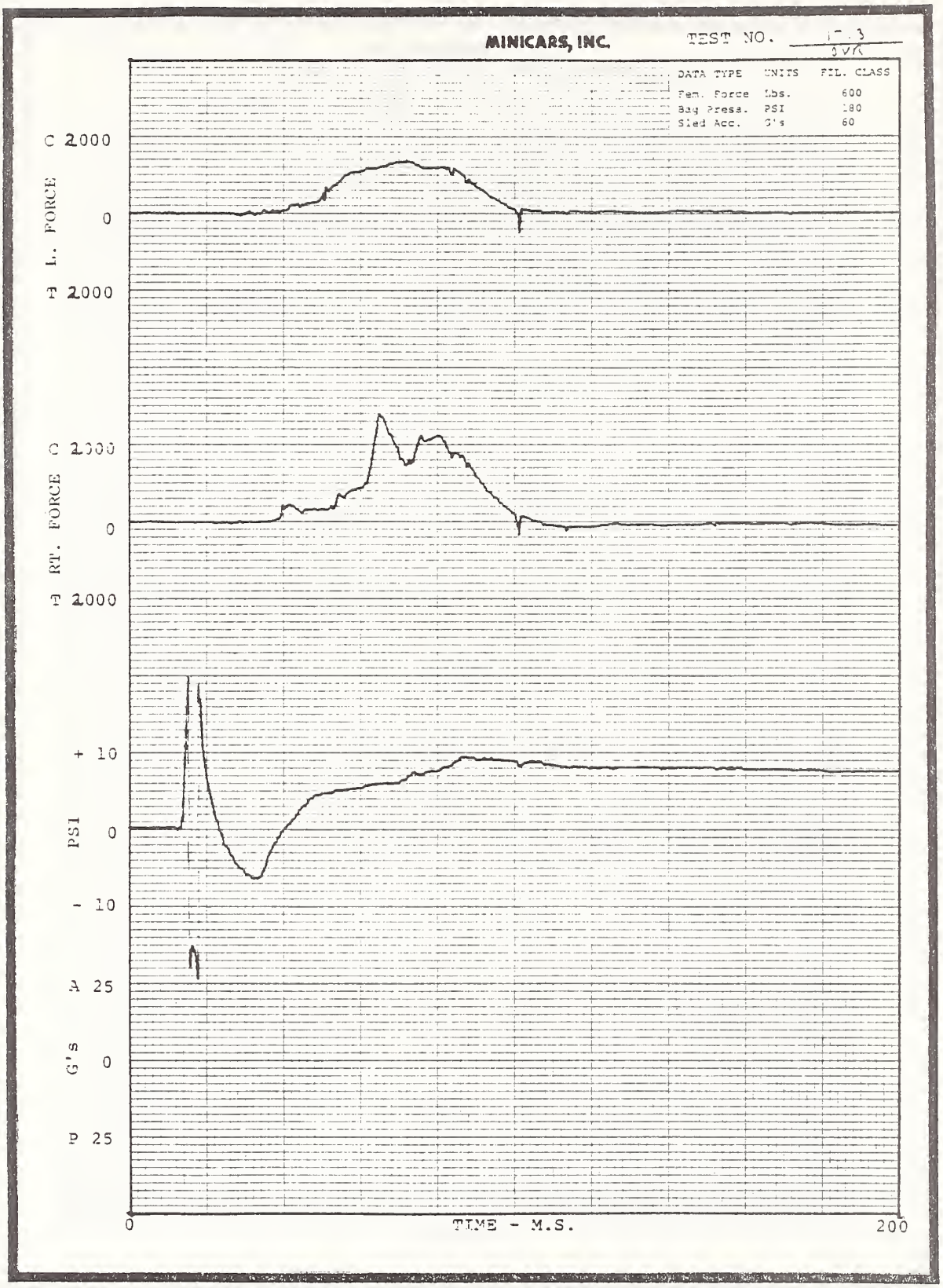

MINICARS, INC.
1697
MID - TRUNK ACC - G'S
1ST ∫
2ND ∫
F.C 180
0
G'S
40
40
FPS
0
25
IN.
0
0
TIME - M.S.
200

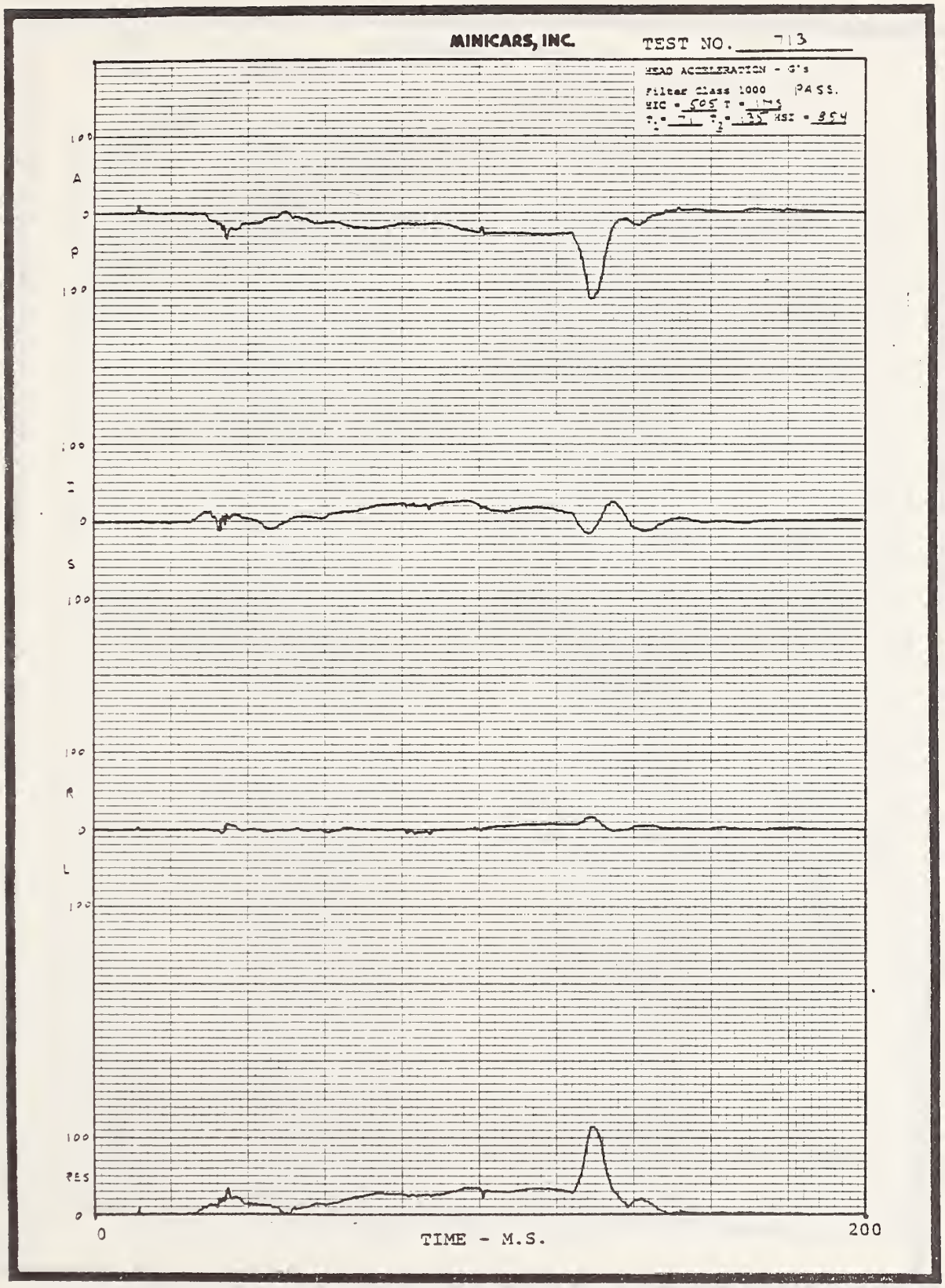

MINICARS, INC.
1697
LEFT 'A' PILLAR ACC-G's
FC. 60
25
A
0
P
25
25
R
0
L
25
25
RES
0
0
TIME - M.S.
200

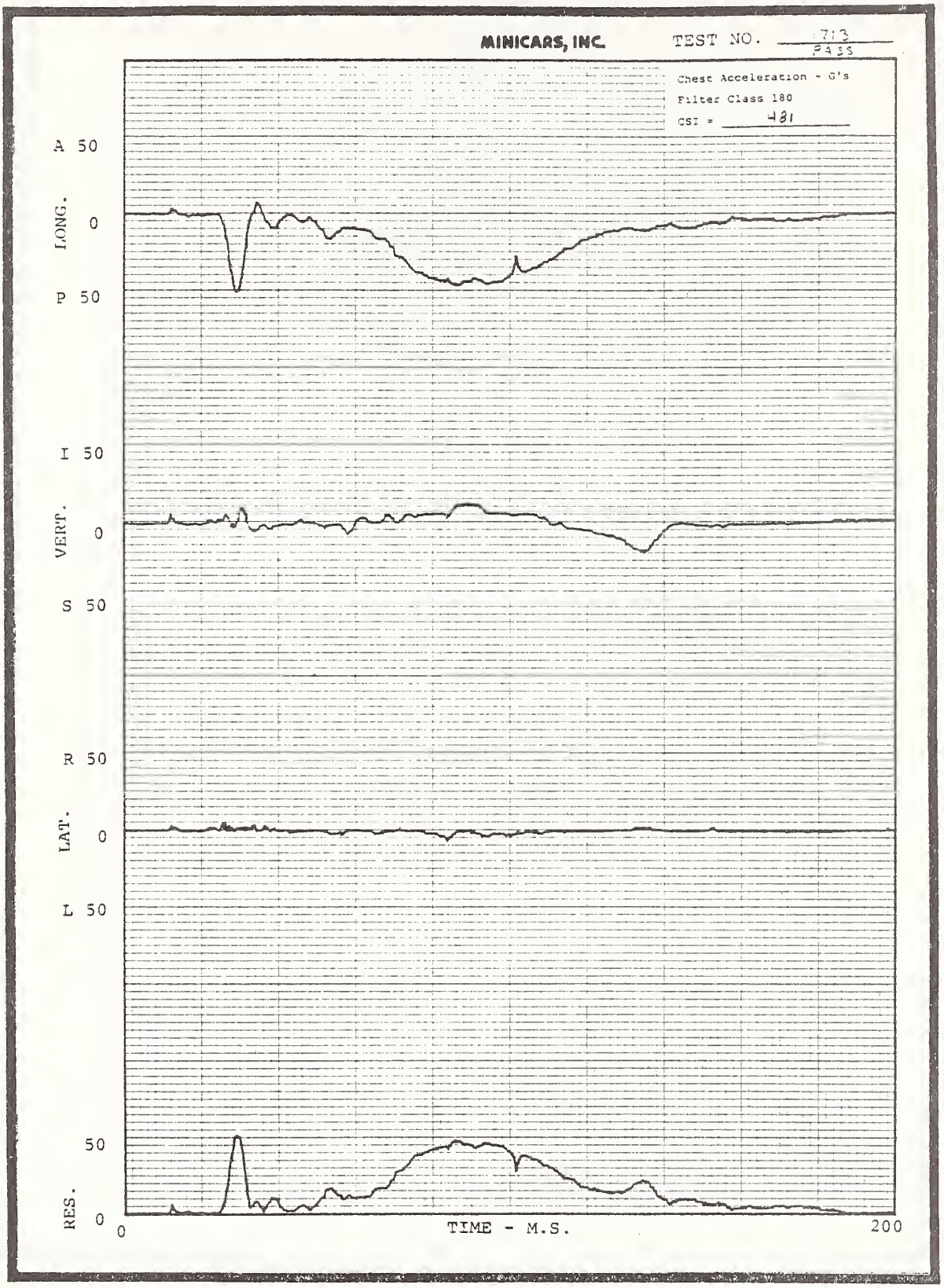

MINICARS, INC.
1697
LEFT 'A' PILLAR ACC - G'S
1ST ∫
2ND ∫
F.C. 180
0
G'S
50
40
FPS
0
25
IN
0
0
TIME - M.S
200

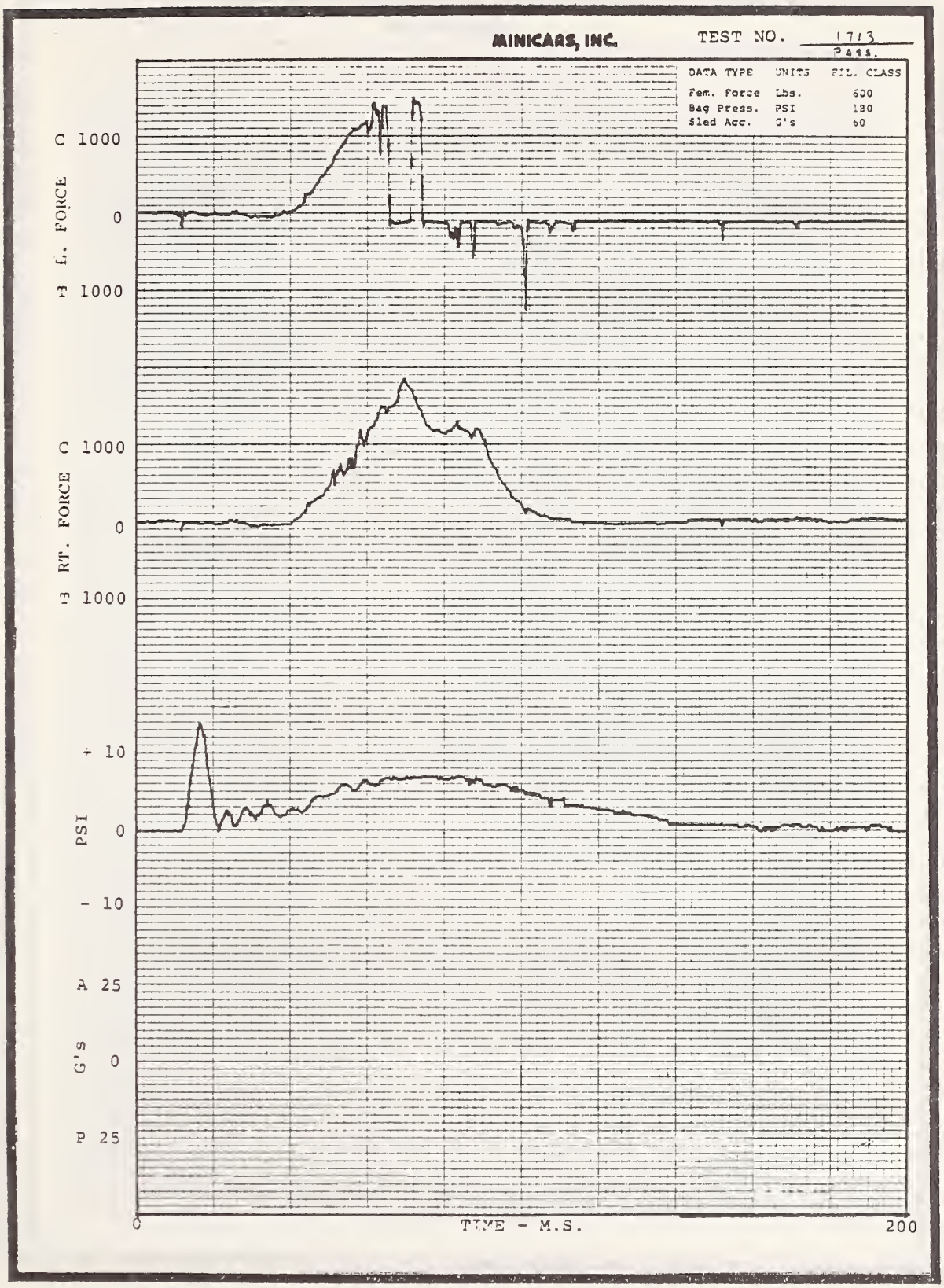

MINICARS, INC.
TEST NO.
Filter Class 1000
50
A
0
P
50
50
I
0
S
50
50
R
0
L
50
ELECTRICAL
50
RES
0
0
TIME - M.S.
200

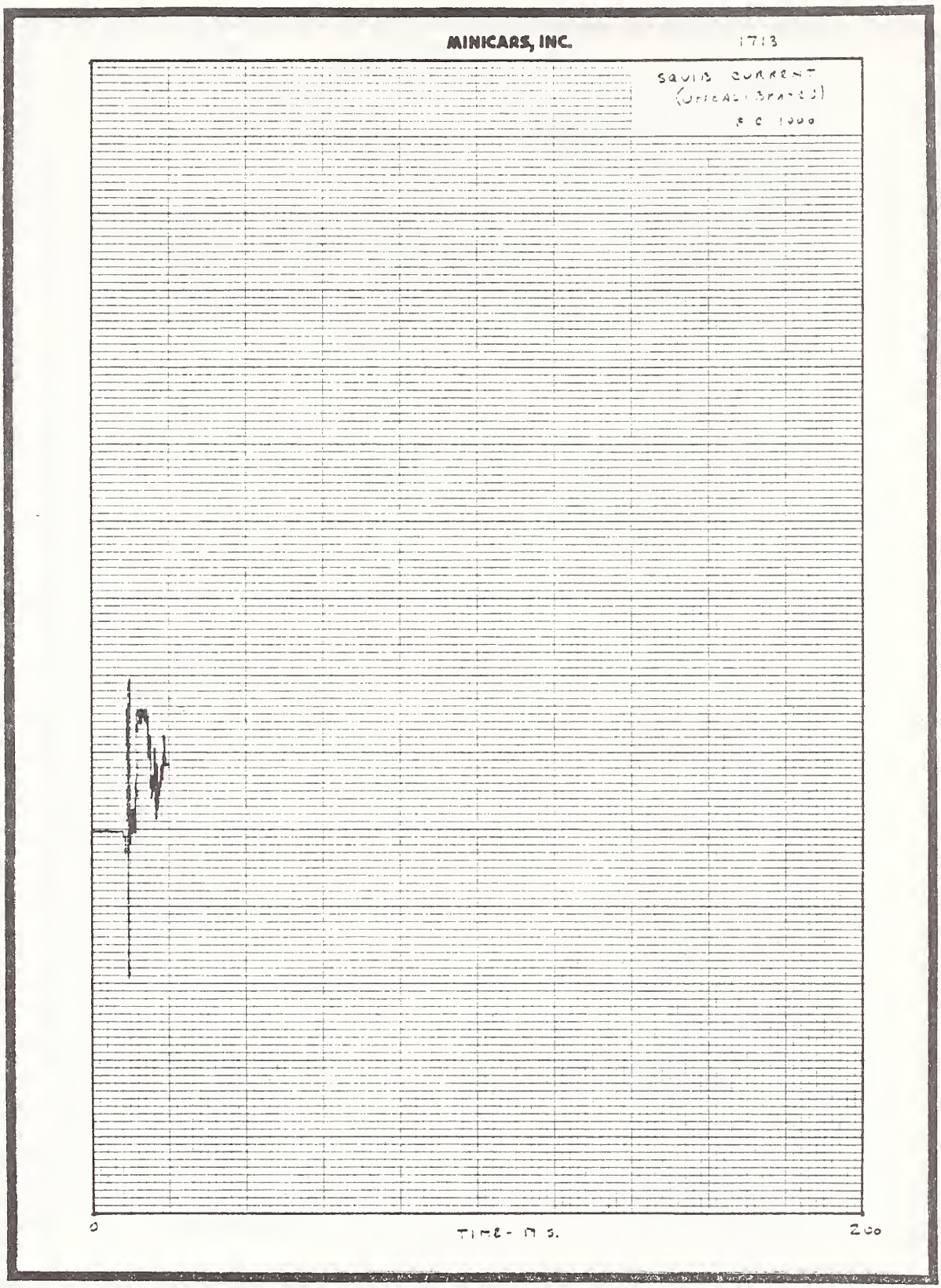

MINICARS, INC.
TEST NO. 1713
DVR
Chest Acceleration - G's
Filter Class 180
CSI = 544
A 50
LONG.
0
P 50
F 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 10
PSI
0
- 10
A 25
G's
0
P 25
0
TIME - M.S.
200

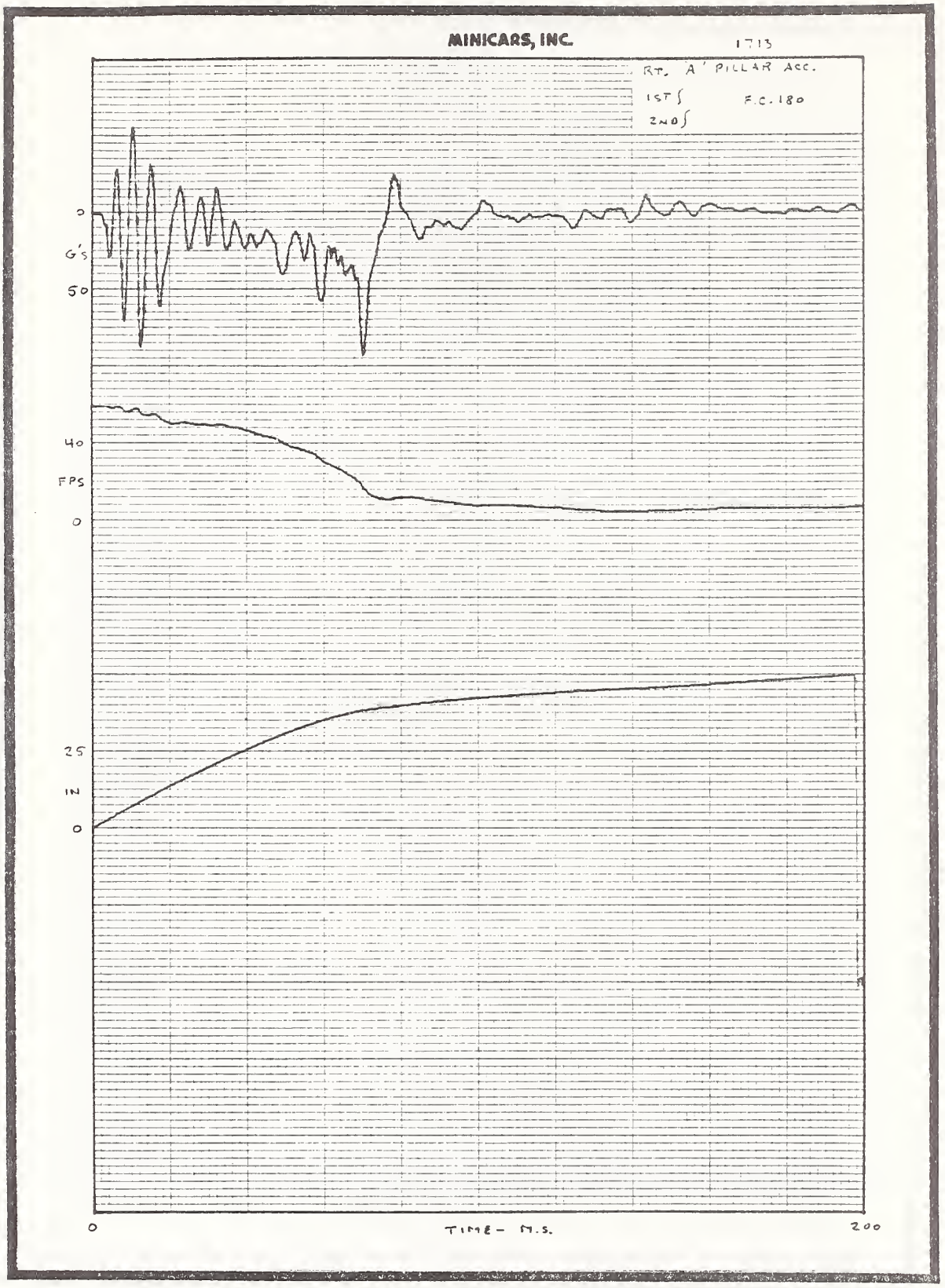

MINICARS, INC.
TEST NO. 713
HEAD ACCELERATION - G's
Filter Class 1000
PASS.
HIC = 505 T = 1MS
HSI = 854
100
A
0
P
100
100
I
0
S
100
100
R
0
L
100
100
RES
0
0
TIME - M.S.
200

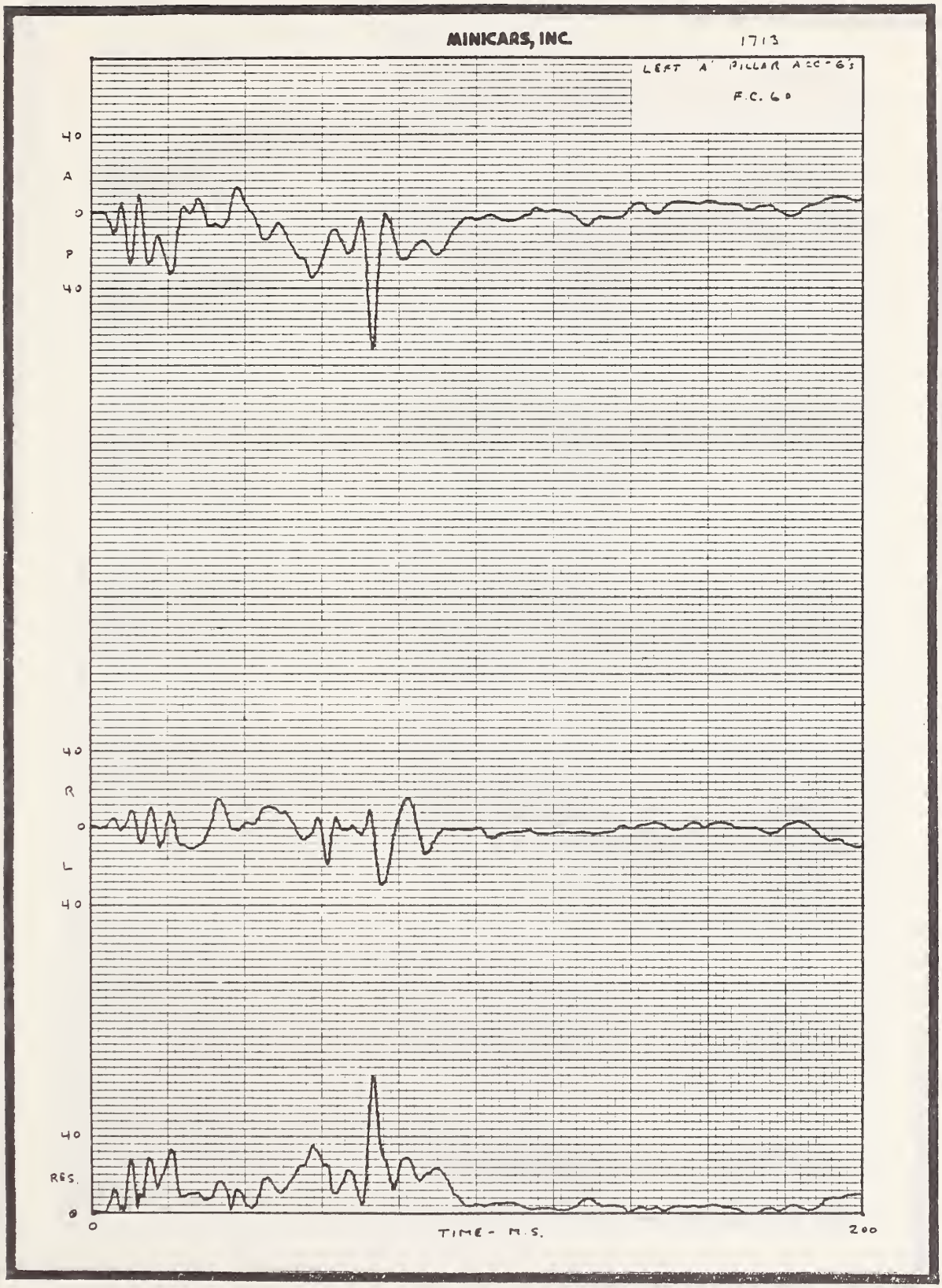

MINICARS, INC.
TEST NO. 1713
PASS
Chest Acceleration - G's
Filter Class 180
CSI = 481
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

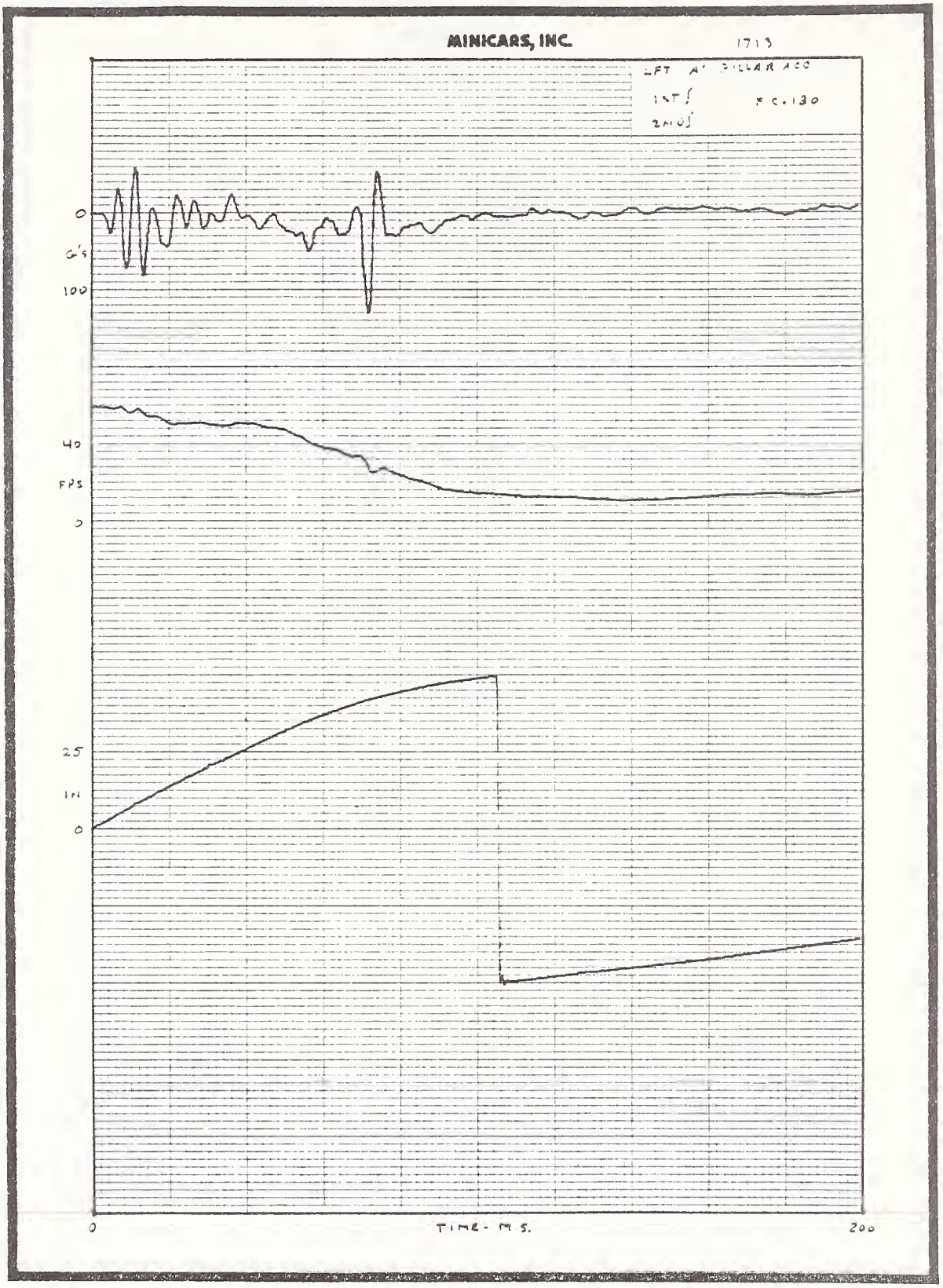

MINICARS, INC.
TEST NO. 1713
PASS.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
1000
0
1000
1000
0
1000
+ 10
PSI 0
- 10
25
G's 0
25
0
TIME - M.S.
200

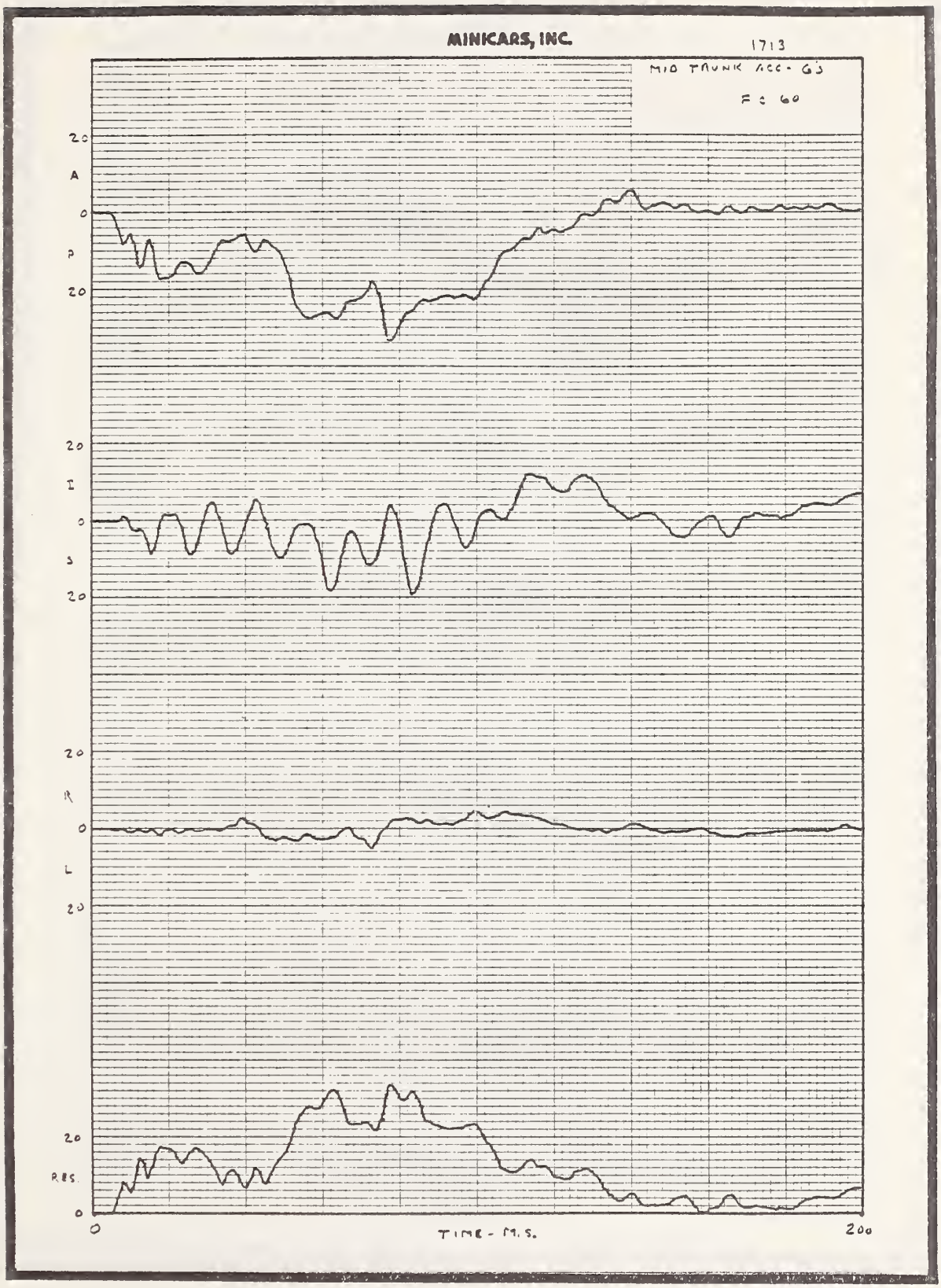

MINICARS, INC.
1713
SQUID CURRENT
0
TIME - MS.
200

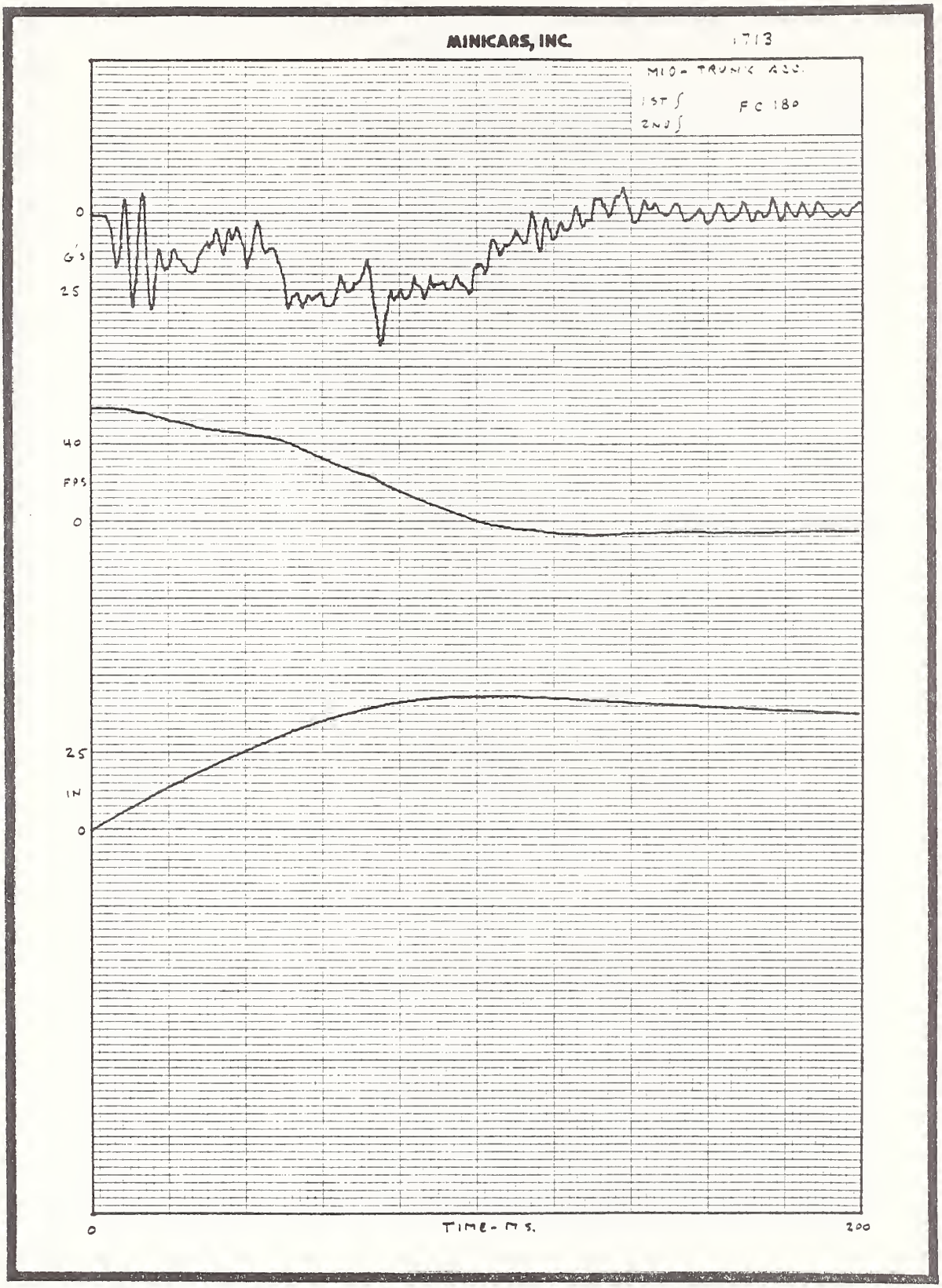
MINICARS, INC.
1713
RT A' PILLAR ACC-G'S
F C 60
40
A
0
P
40
40
R
0
L
40
40
RES.
0
0
TIME - M.S.
200

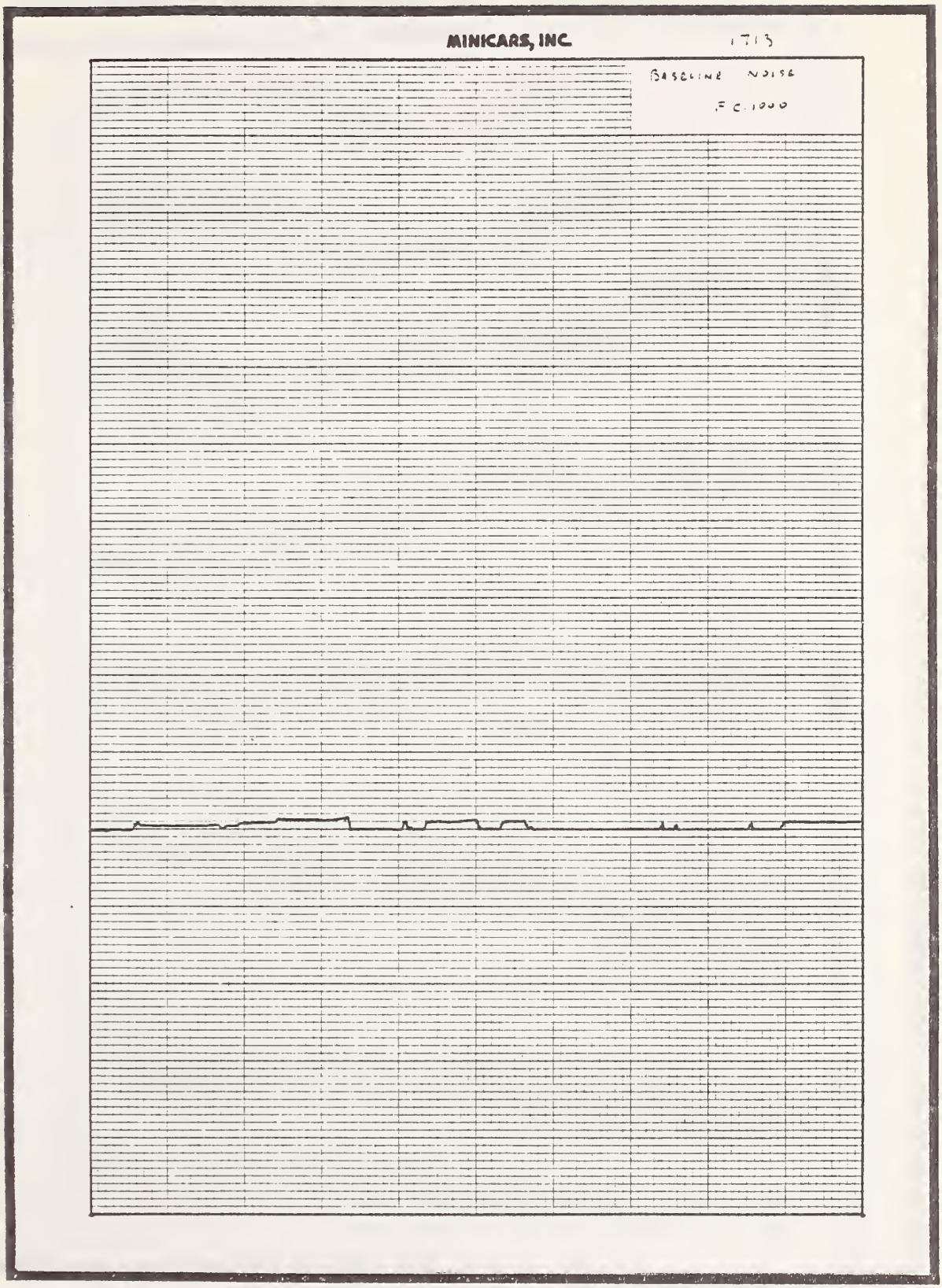

MINICARS, INC.
1713
RT. A' PILLAR ACC.
1ST ∫
2ND ∫
F.C. 180
0
G'S
50
40
FPS
0
25
IN
0
0
TIME - M.S.
200

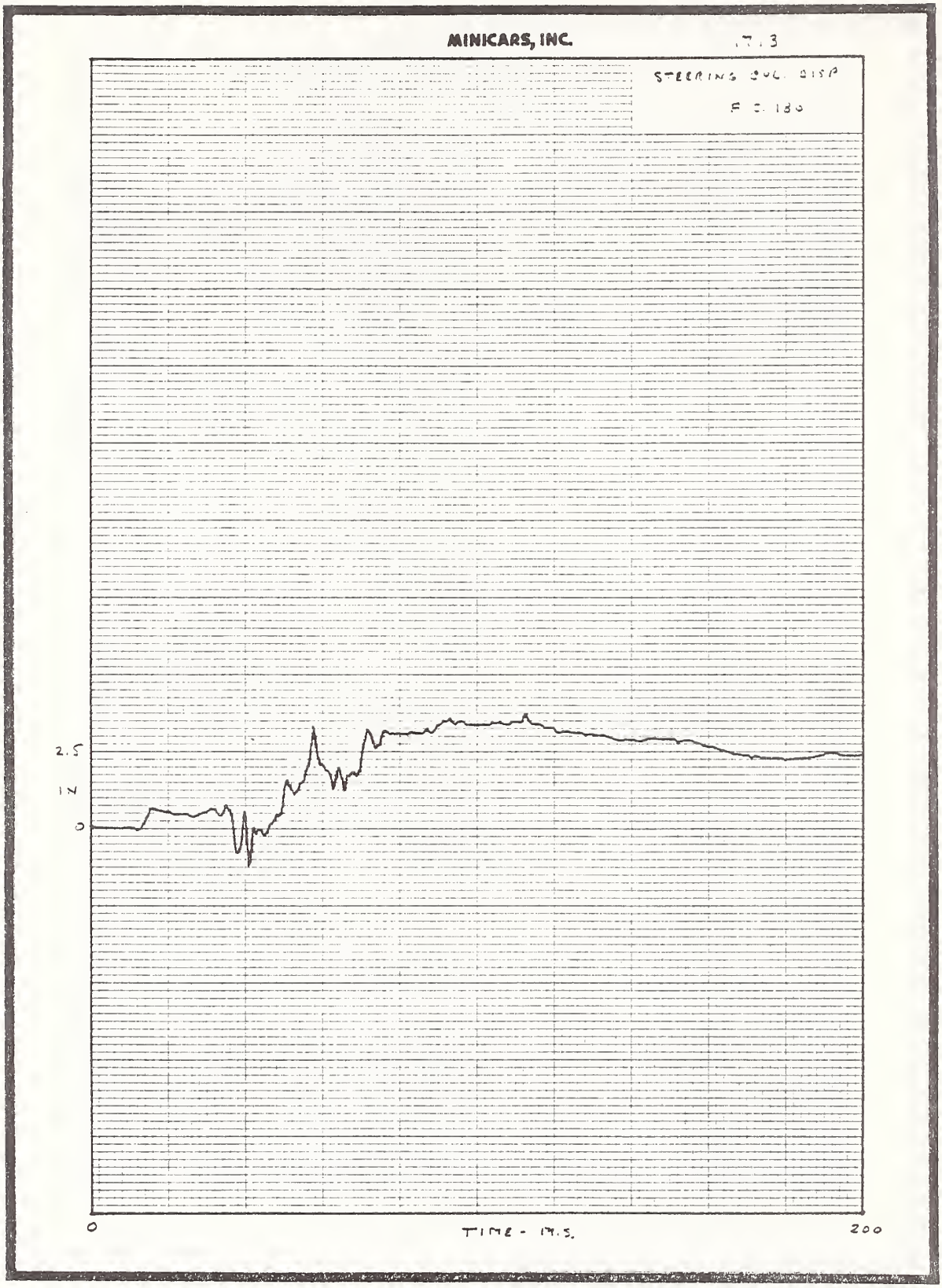

MINICARS, INC.
1713
LEFT A' PILLAR ACC-G's
F.C. 60
40
A
0
P
40
40
R
0
L
40
40
RES.
0
0
TIME - M.S.
200

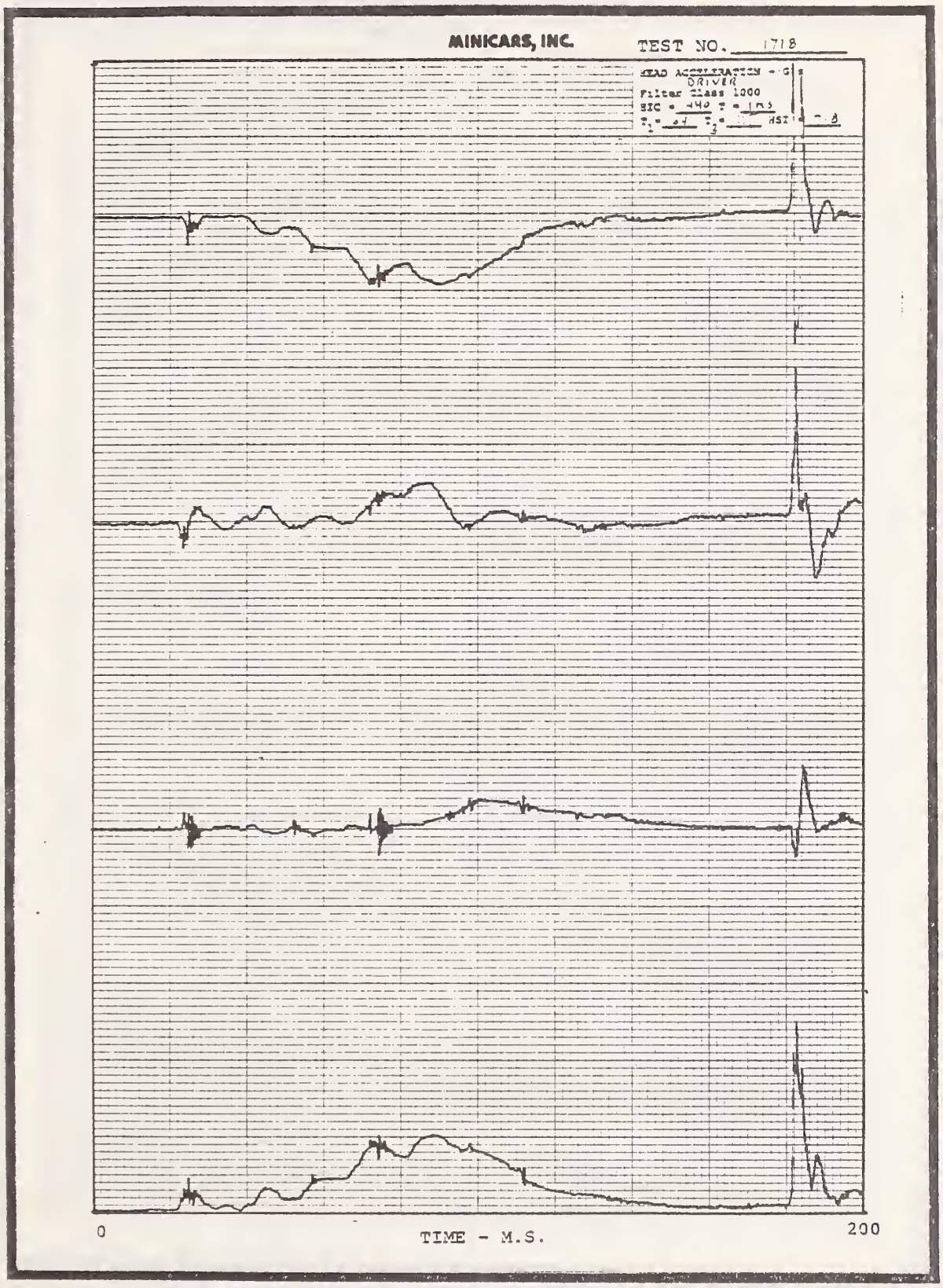

MINICARS, INC.
1713
LEFT A' PILLAR ACC
1ST
2ND
FC.130
0
G's
100
40
FPS
0
25
IN
0
0
TIME - M S.
200

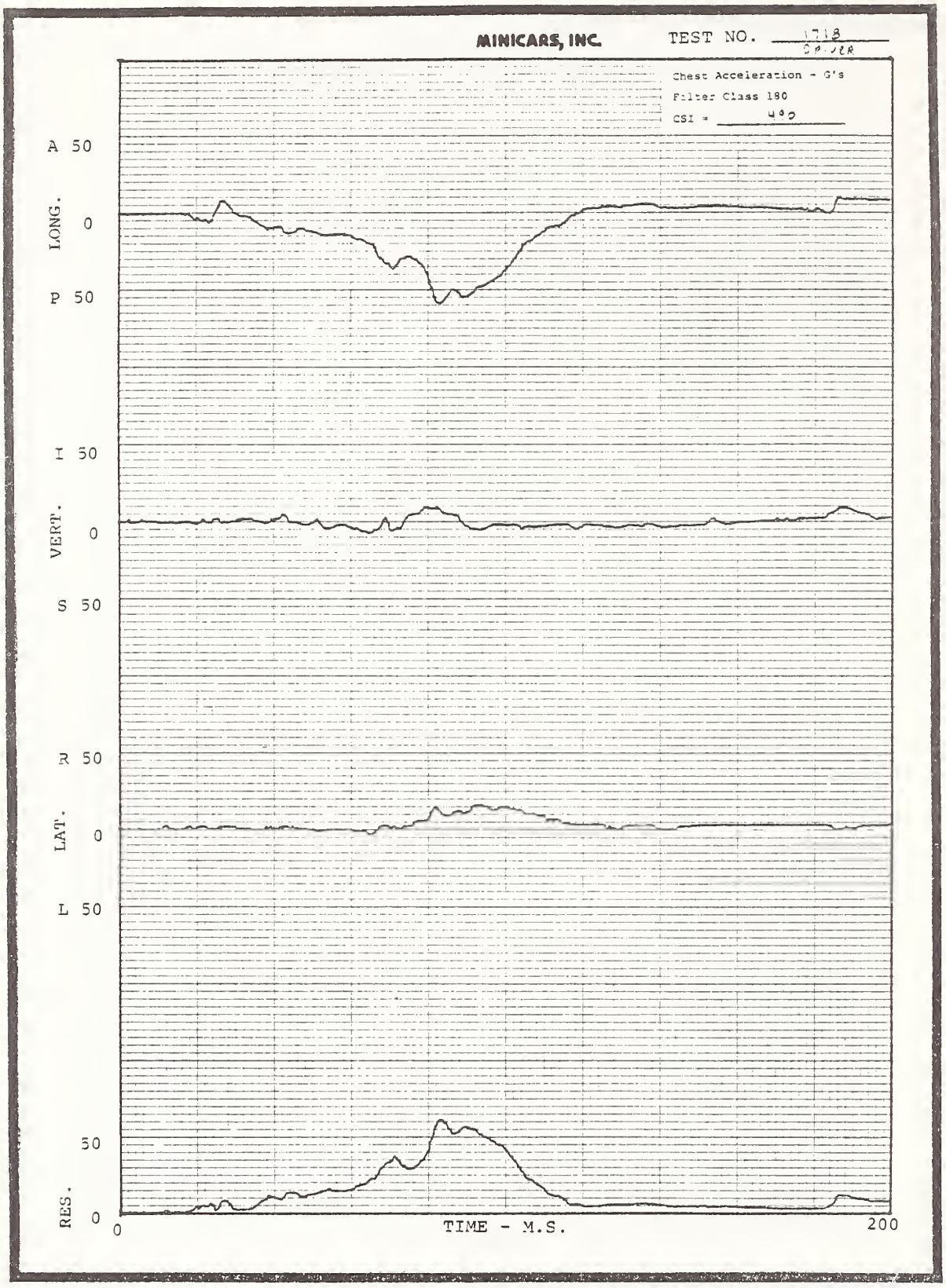

MINICARS, INC.
1713
MID TRUNK ACC - G'S
F = 60
20
A
0
P
20
20
I
0
S
20
20
R
0
L
20
20
RES.
0
0
TIME - M.S.
200

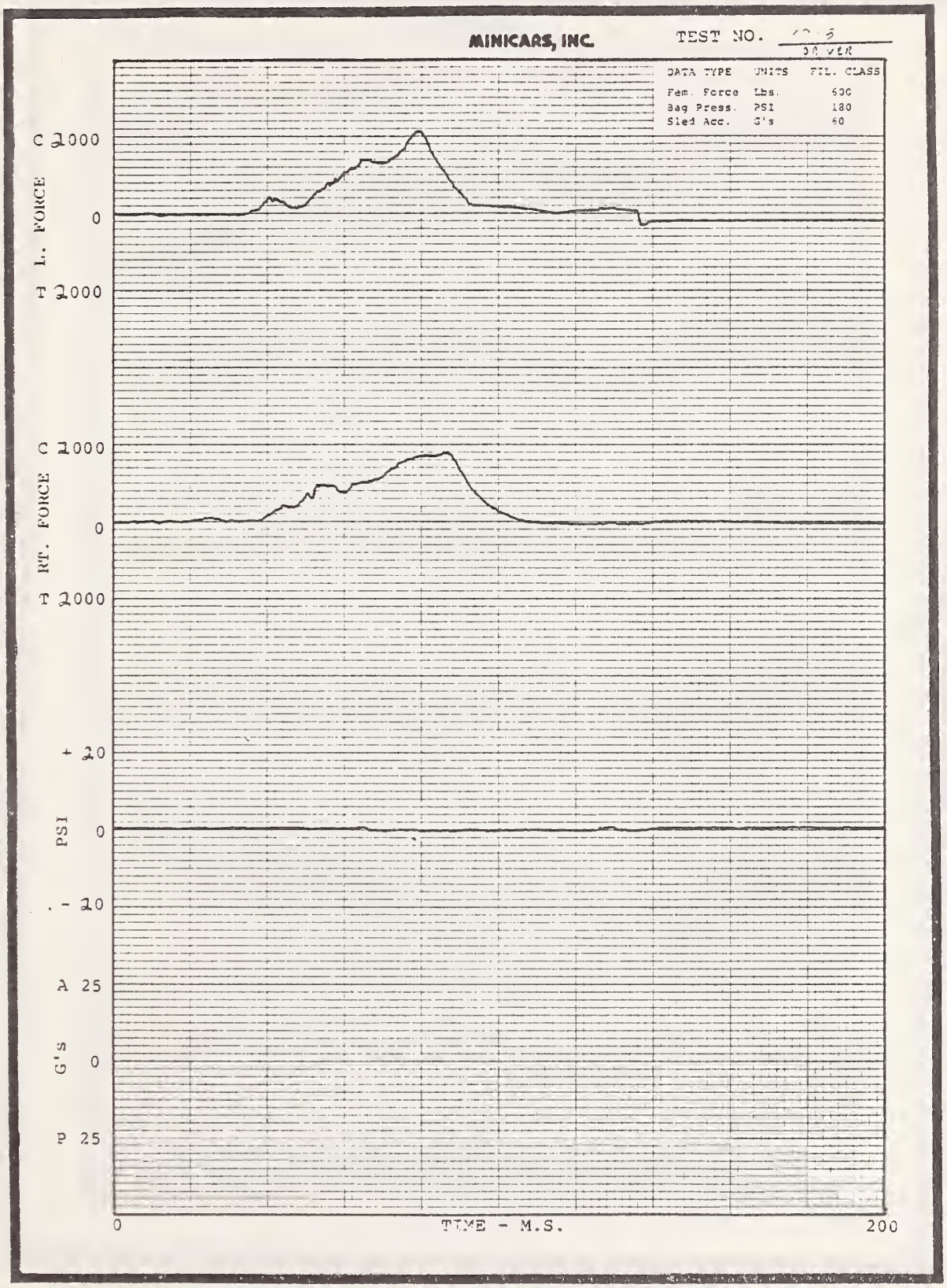

MINICARS, INC.
1713
MID-TRUNK ACC.
1ST ∫
2ND ∫
FC 180
0
G'S
25
40
FPS
0
25
IN
0
0
TIME-MS.
200

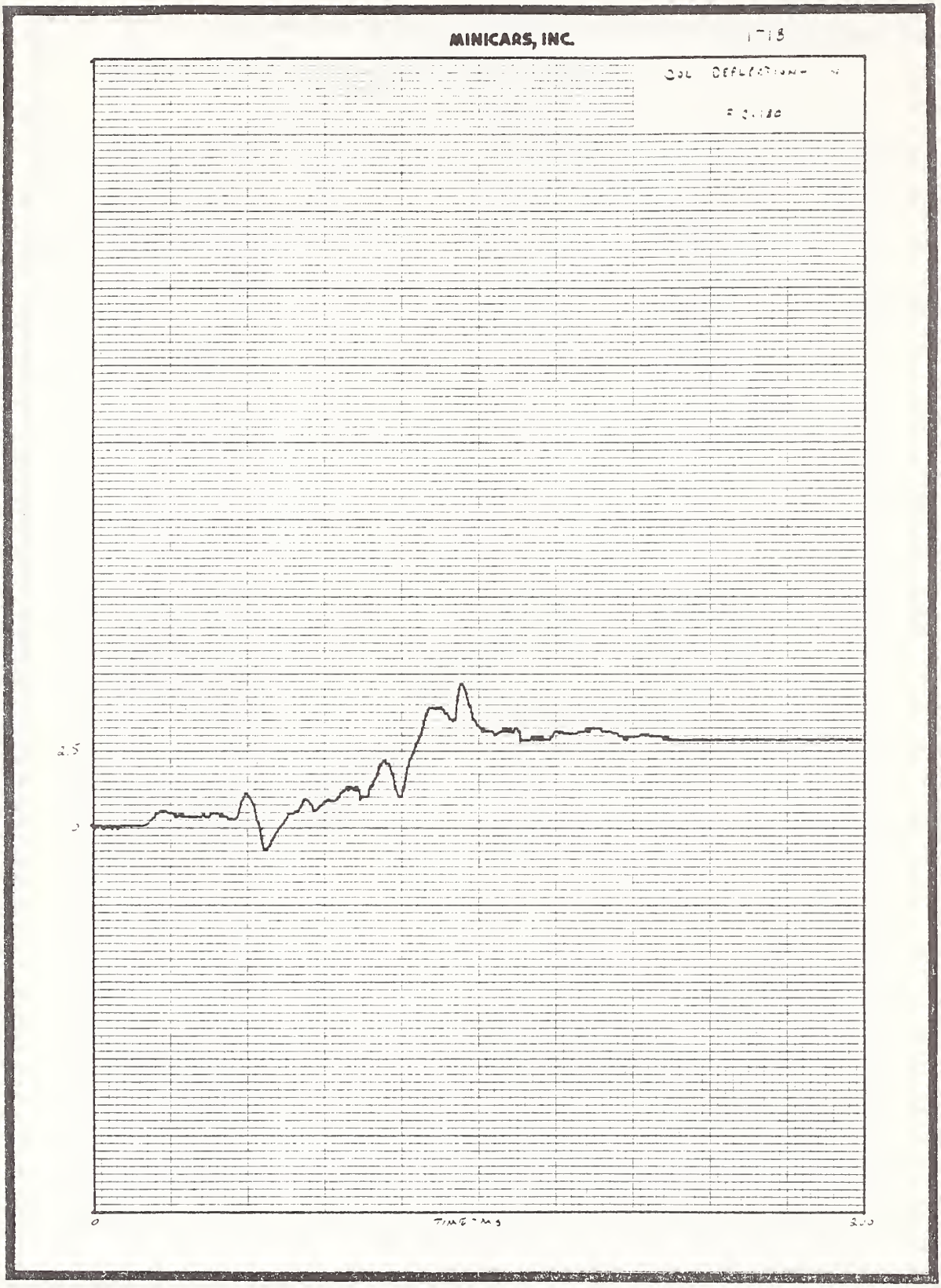

MINICARS, INC.
BASELINE NOISE

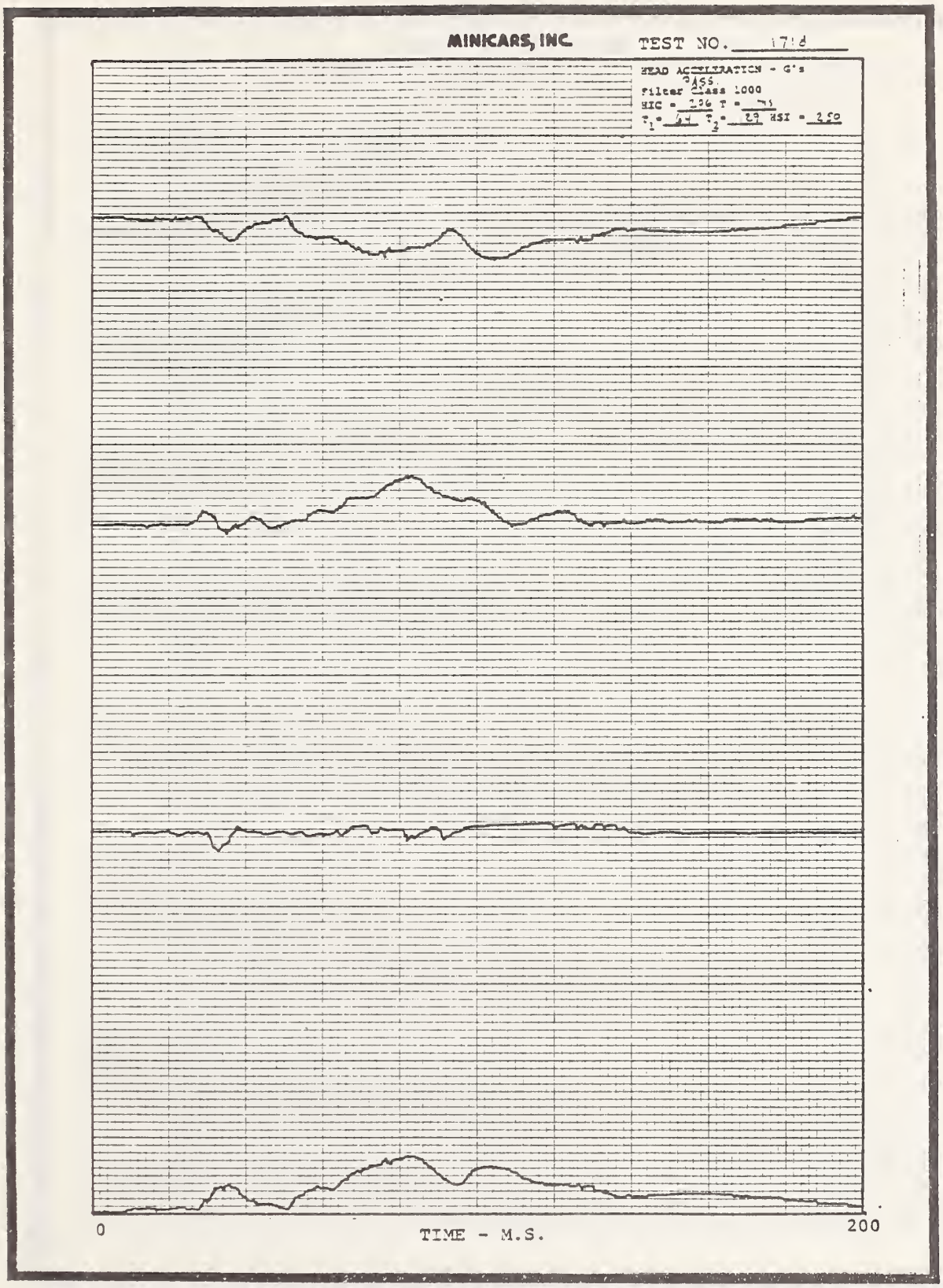

MINICARS, INC.
STEERING COL. DISP
2.5
0
0
TIME - MS.
200

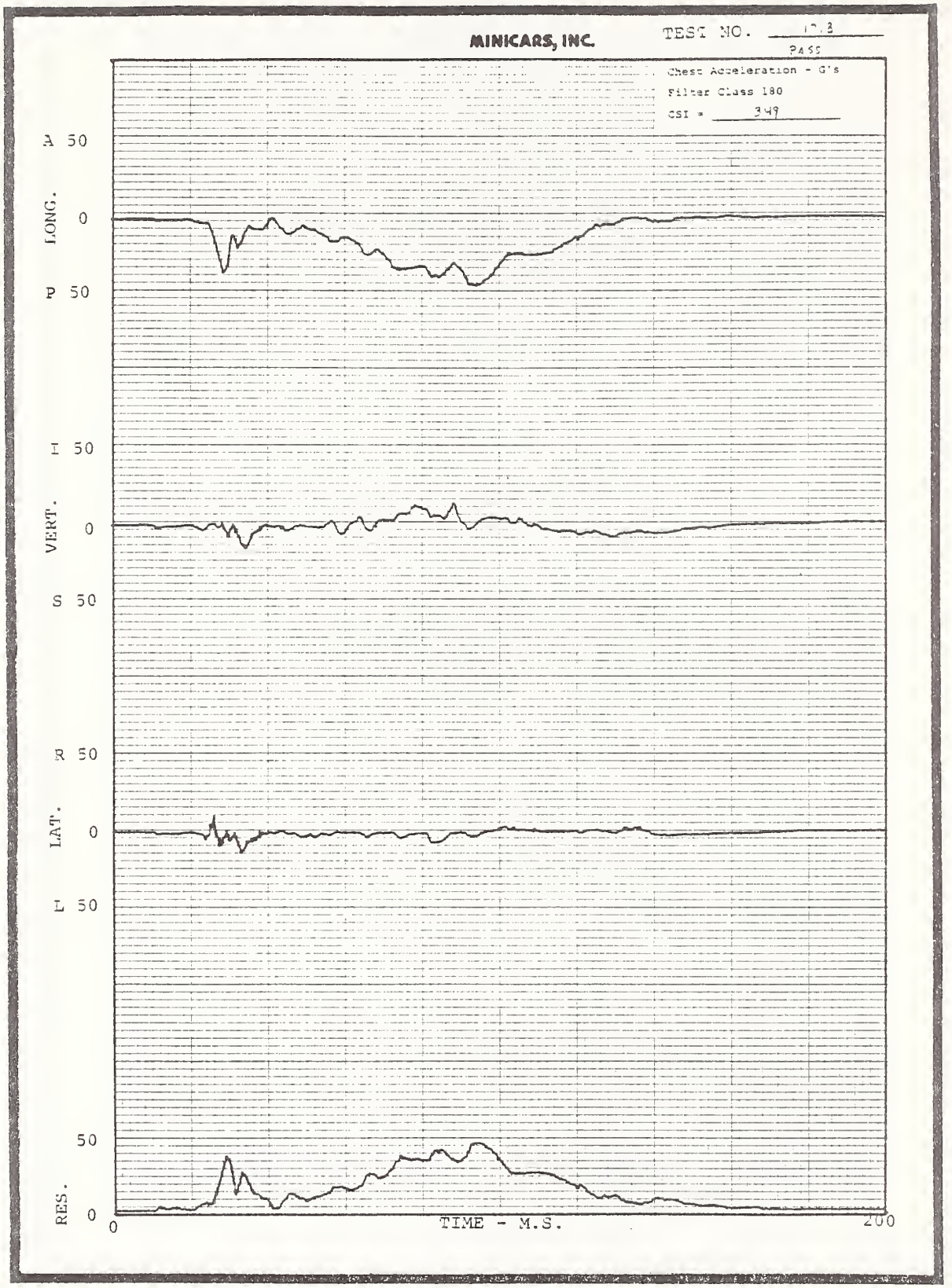

MINICARS, INC.
TEST NO. 1718
DRIVER
Filter Class 1000
0
TIME - M.S.
200

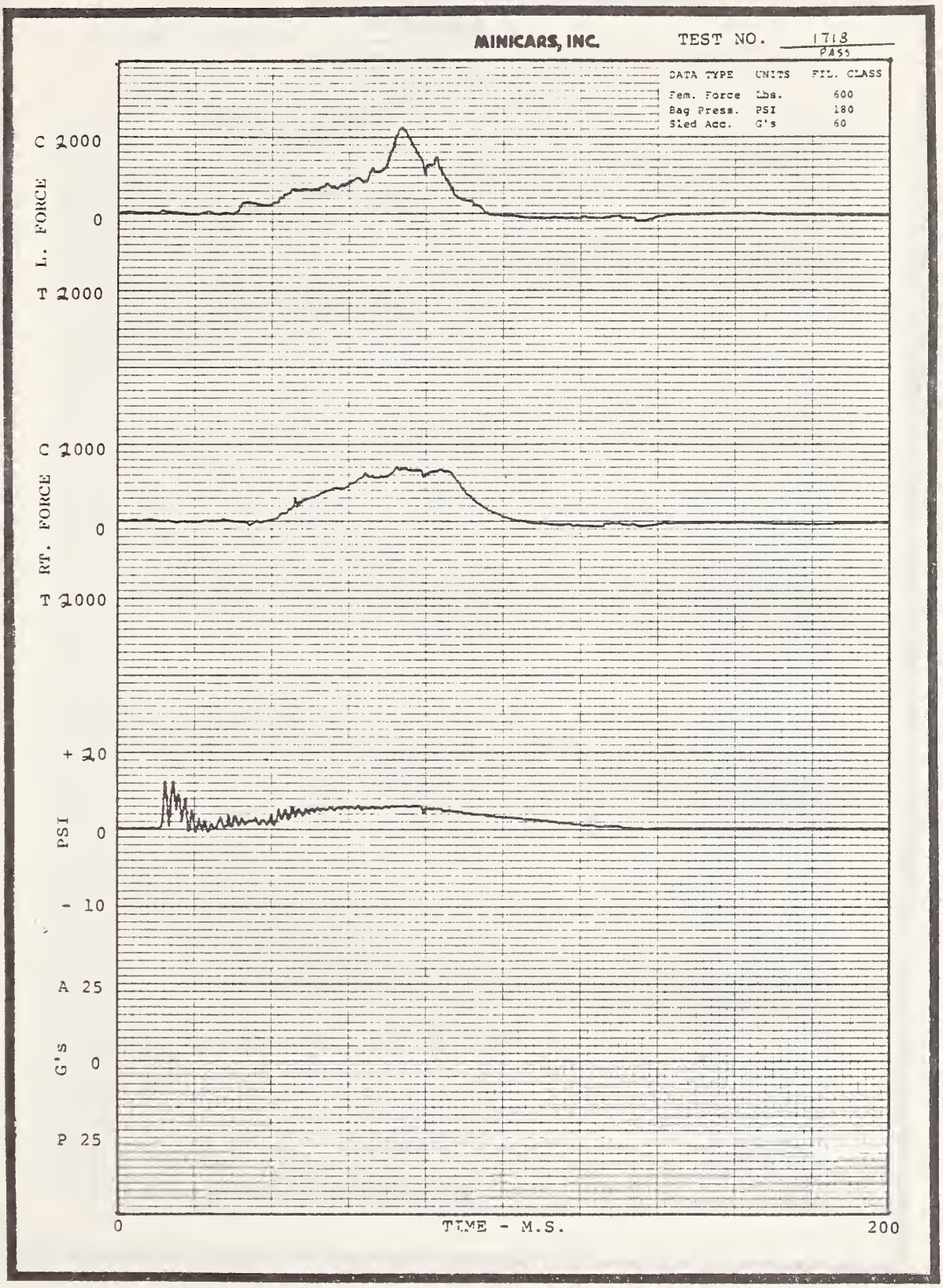

MINICARS, INC.
TEST NO.
Chest Acceleration - G's
Filter Class 180
CSI =
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

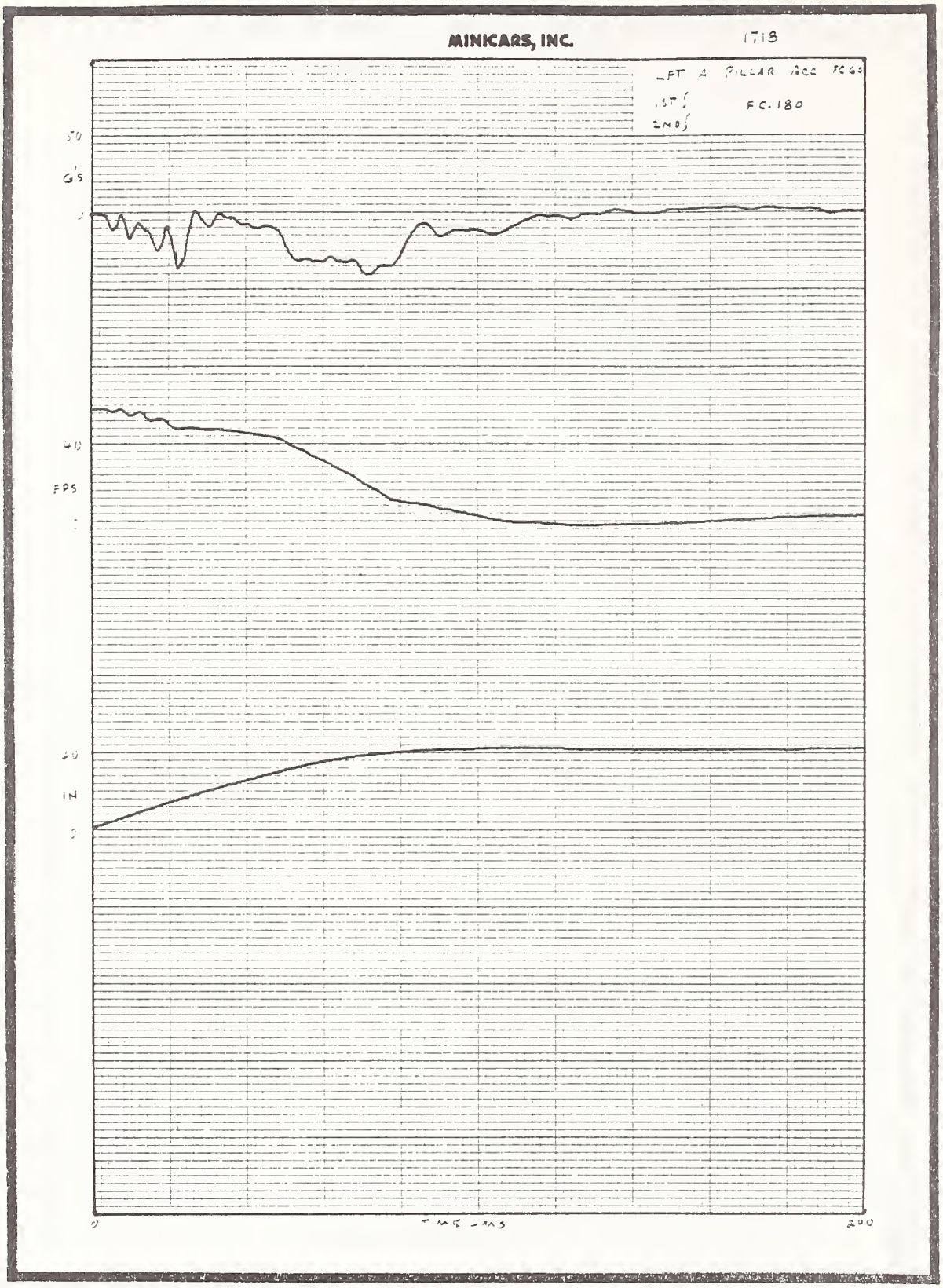

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 20
PSI
0
- 20
A 25
G's
0
P 25
0
TIME - M.S.
200

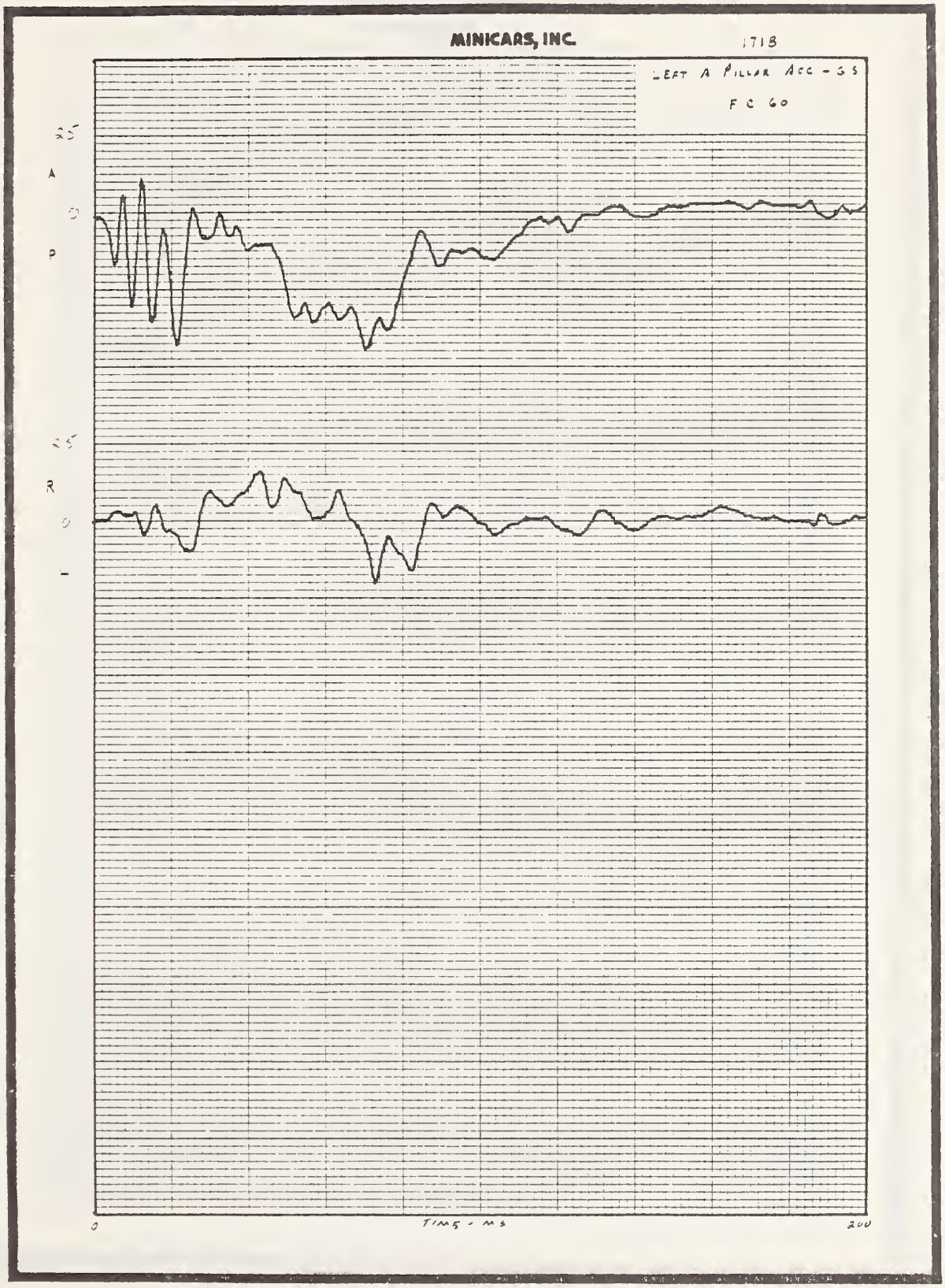

MINICARS, INC.
2.5
0
0
TIME - MS
200

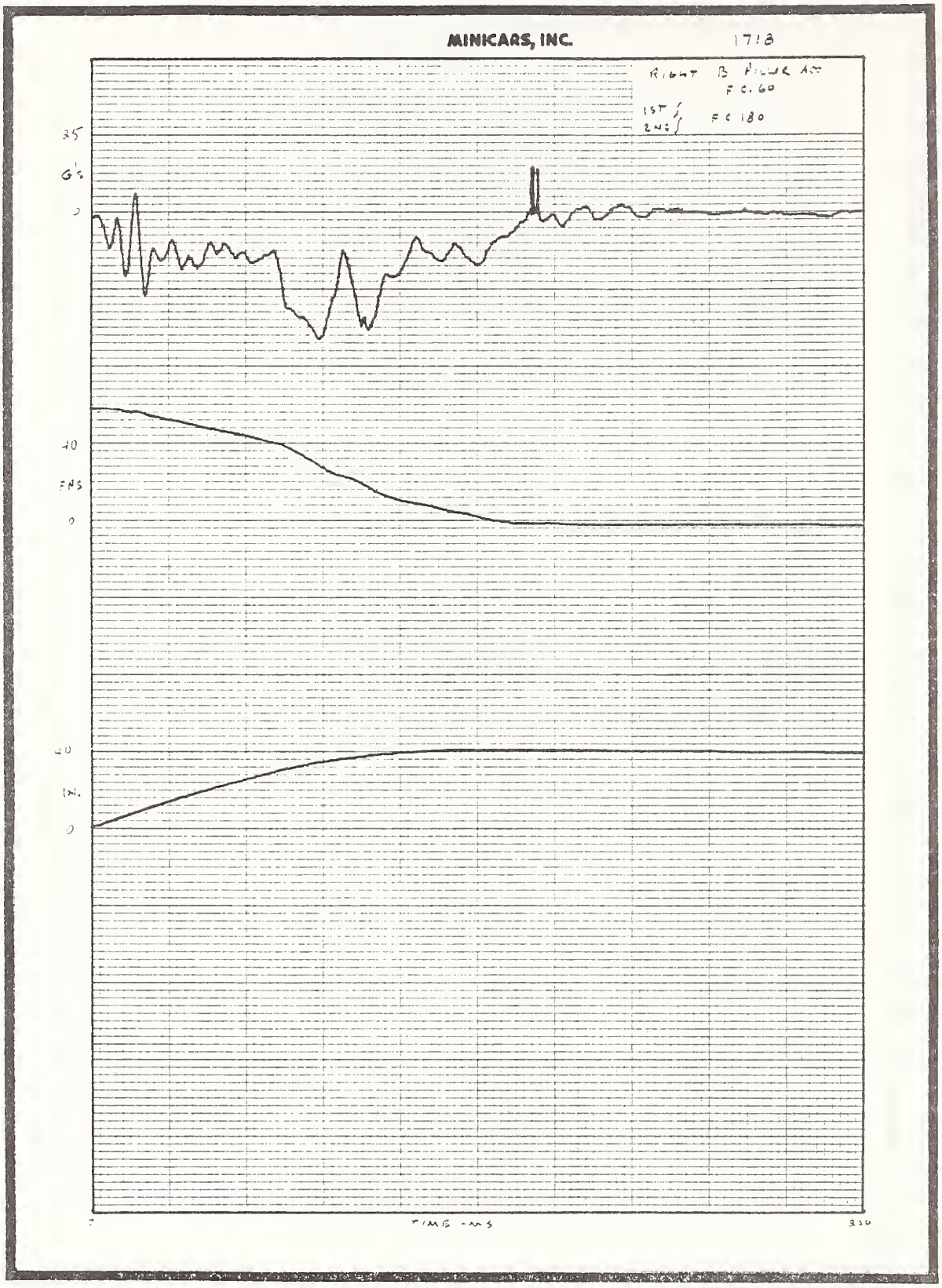

MINICARS, INC.
TEST NO. 171d
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 296 T = 75
T1 = 44 T2 = 29 HSI = 2.50
0
TIME - M.S.
200

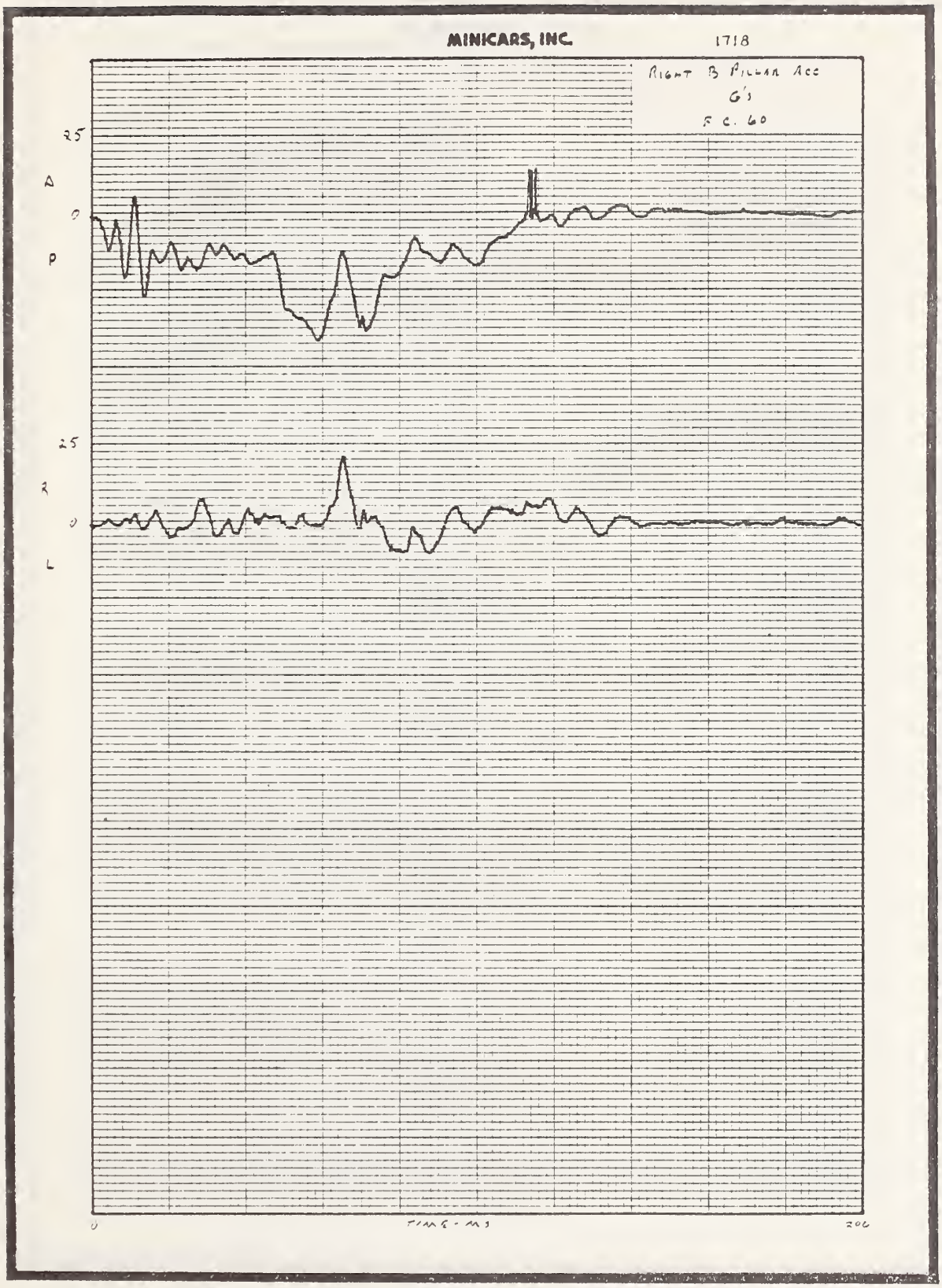

MINICARS, INC.
TEST NO.
PASS
Chest Acceleration - G's
Filter Class 180
CSI =
349
A 50
LONG.
0
P 50
H 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

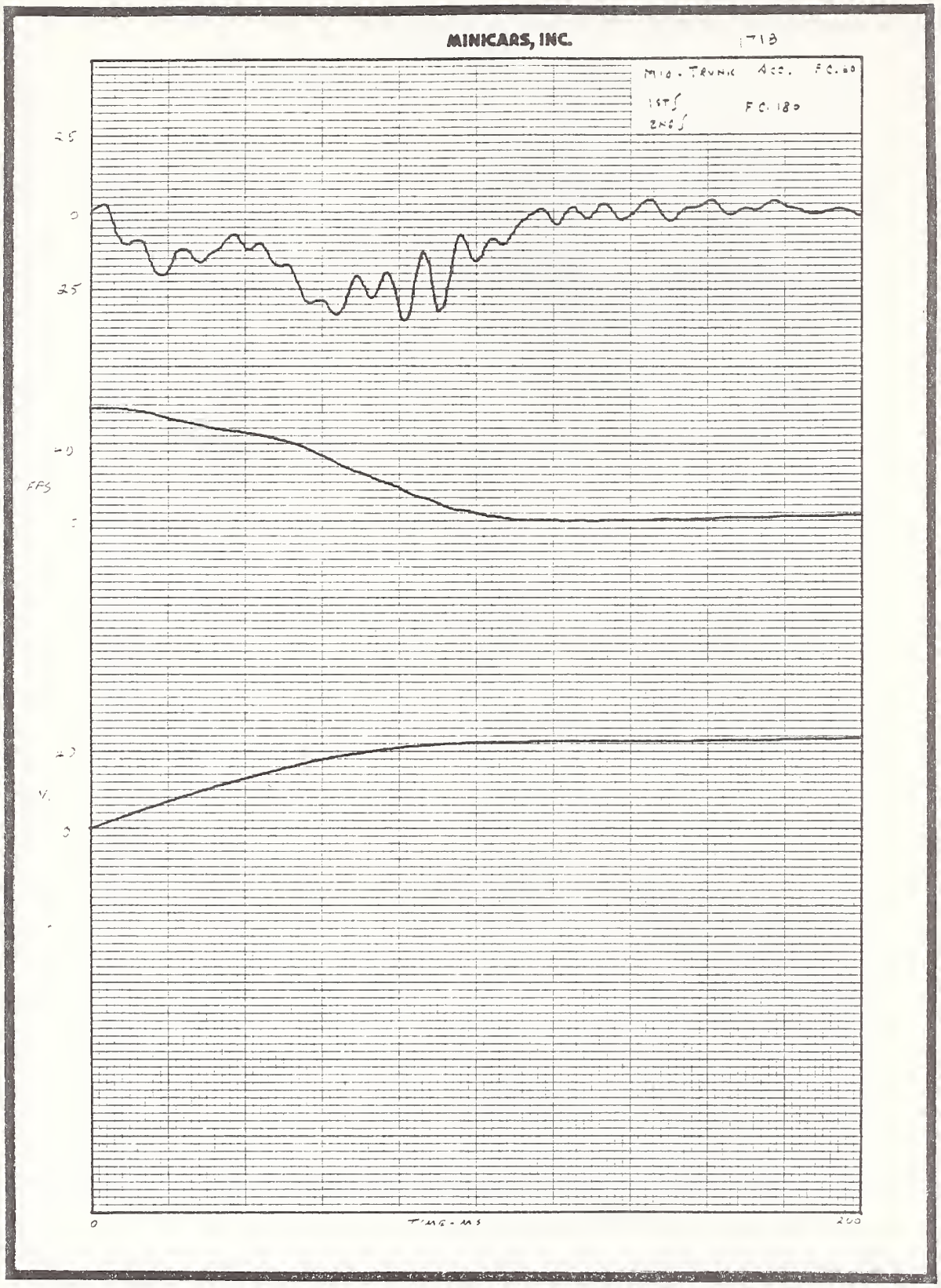

MINICARS, INC.
TEST NO. 1718
PASS
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 2000
L. FORCE
0
T 2000
C 2000
RT. FORCE
0
T 2000
+ 20
PSI
0
- 10
A 25
G's
0
P 25
0
TIME - M.S.
200

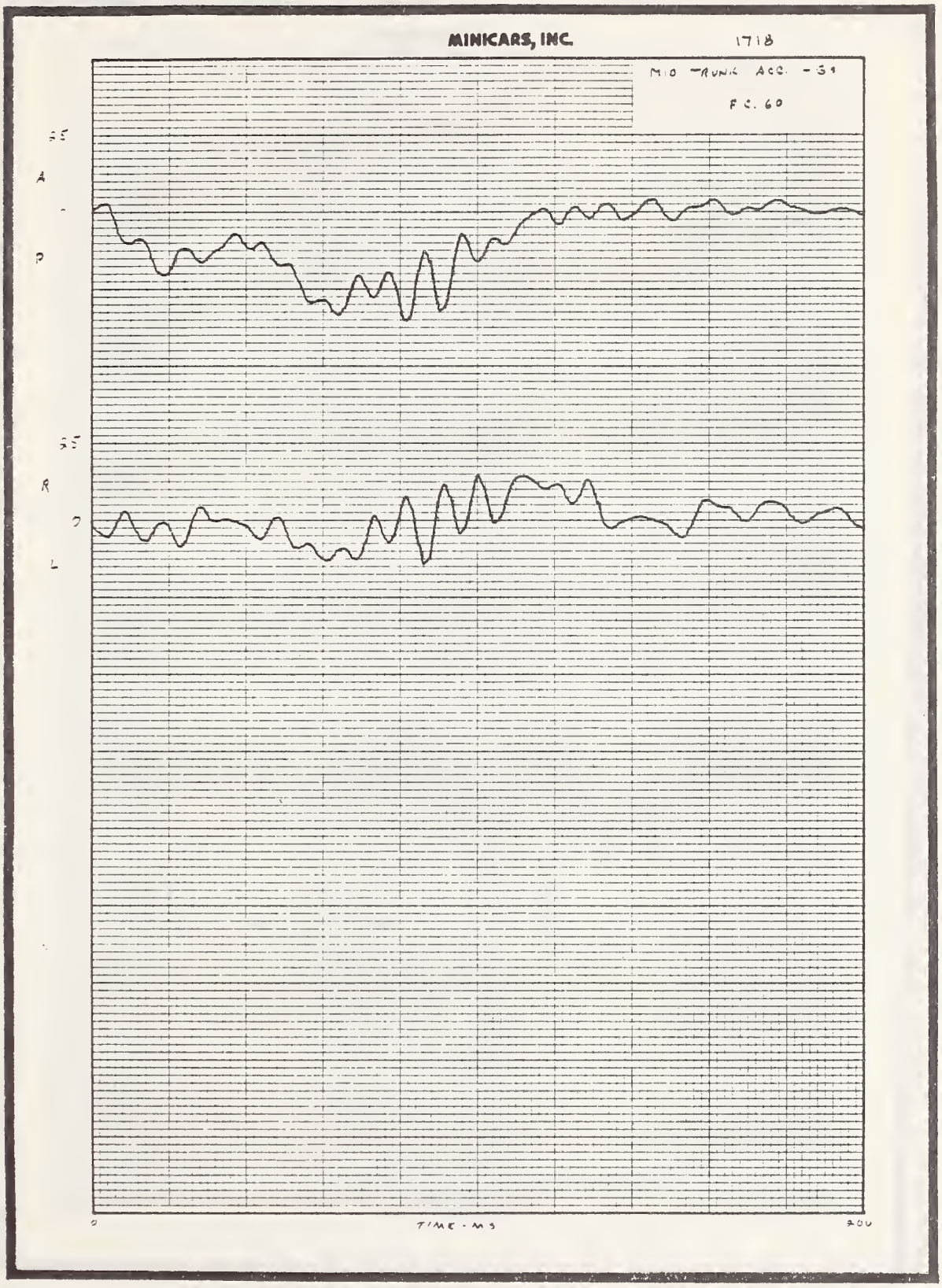

MINICARS, INC.
1718
LFT A PILLAR ACC FC60
1ST
2ND
FC-180
50
G'S
0
40
FPS
0
40
IN
0
0
TIME - MS
200

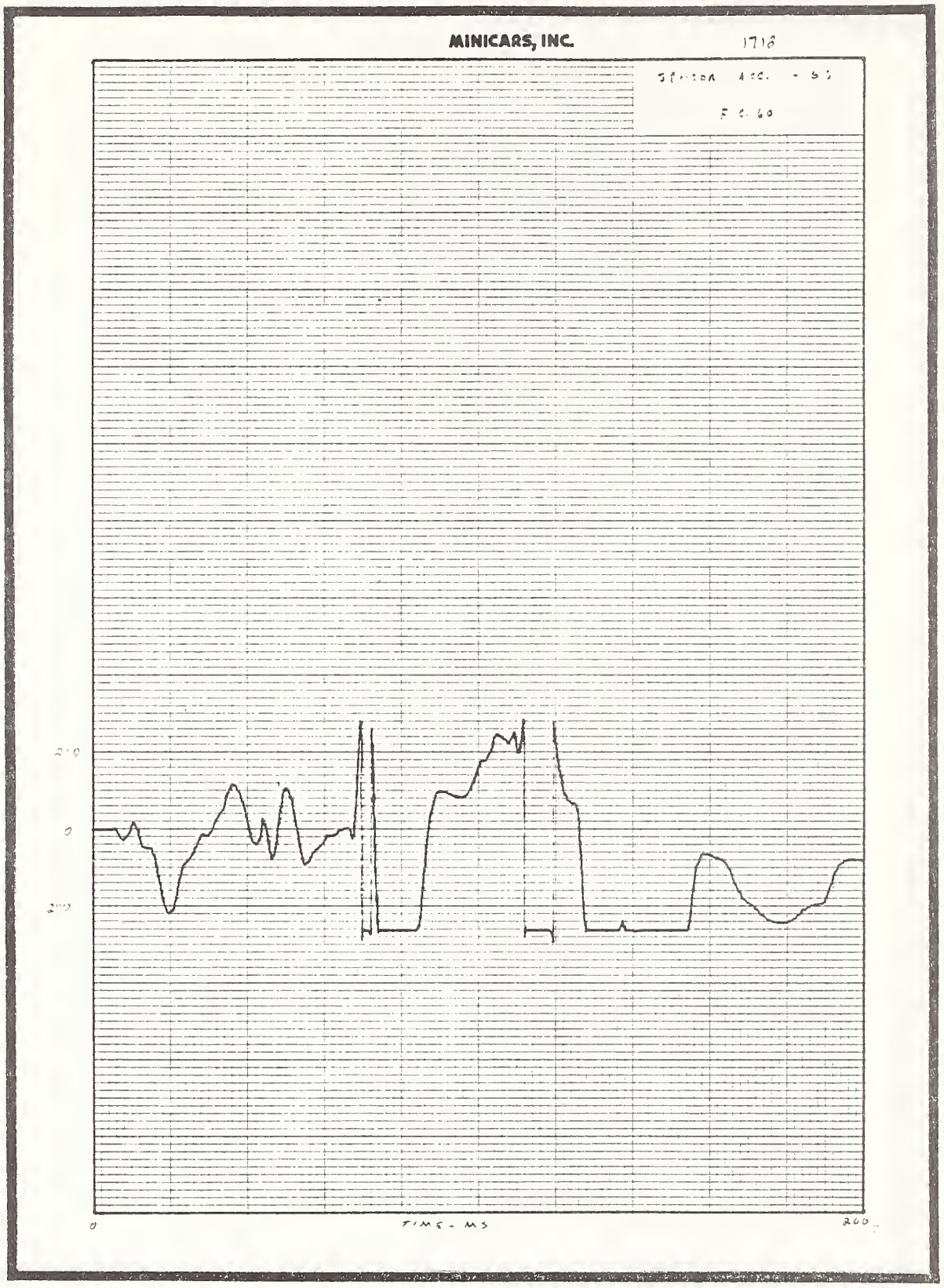

MINICARS, INC.
1718
LEFT A PILLAR ACC - GS
F C 60
25
A
0
P
25
R
0
L
0
TIME - MS
200

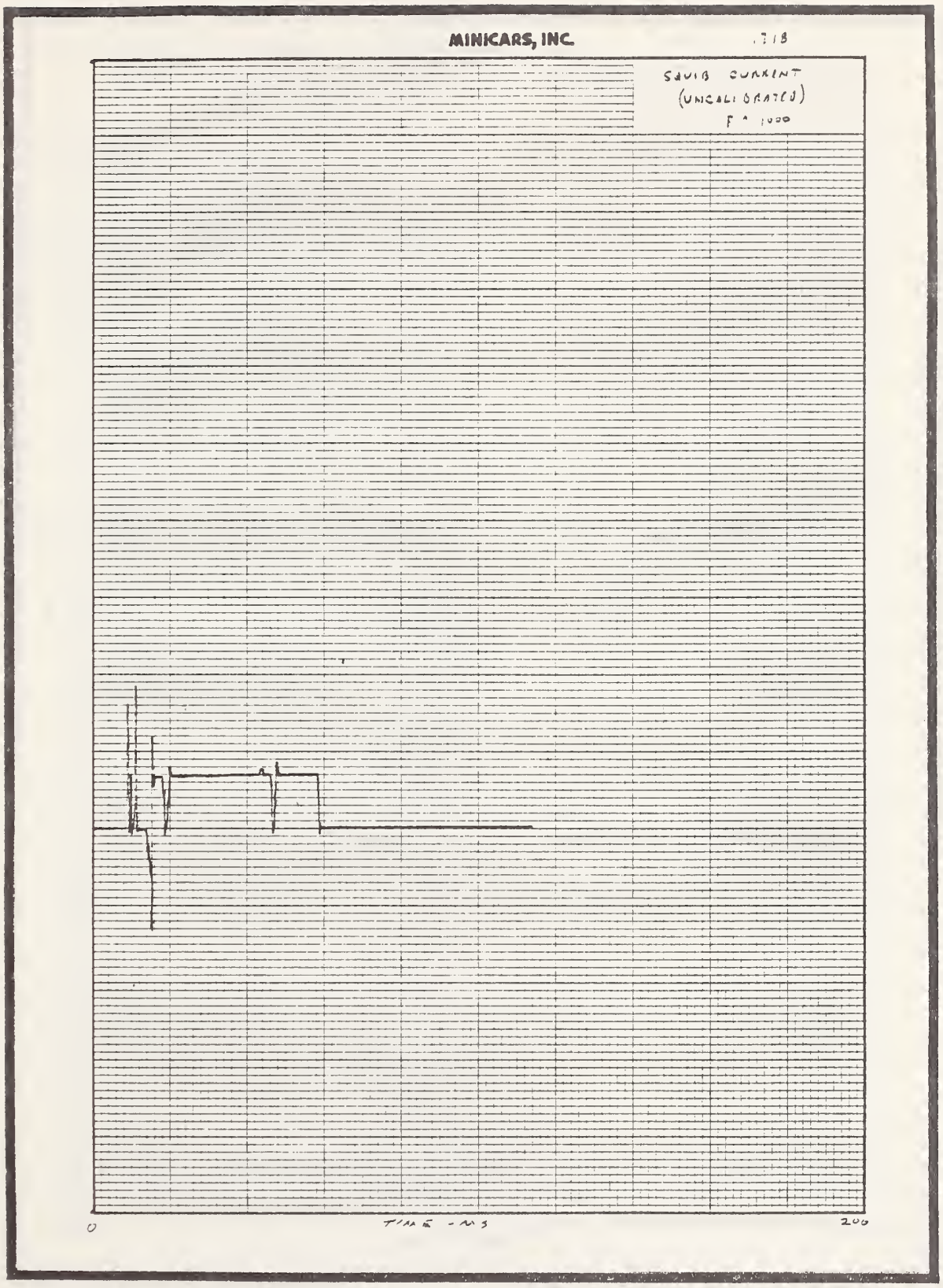

MINICARS, INC.
1718
RIGHT B PILLAR AT
FC.60
1ST &
2ND
FC 180
35
G'S
0
40
FPS
0
40
IN.
0
TIME - MS
0
330

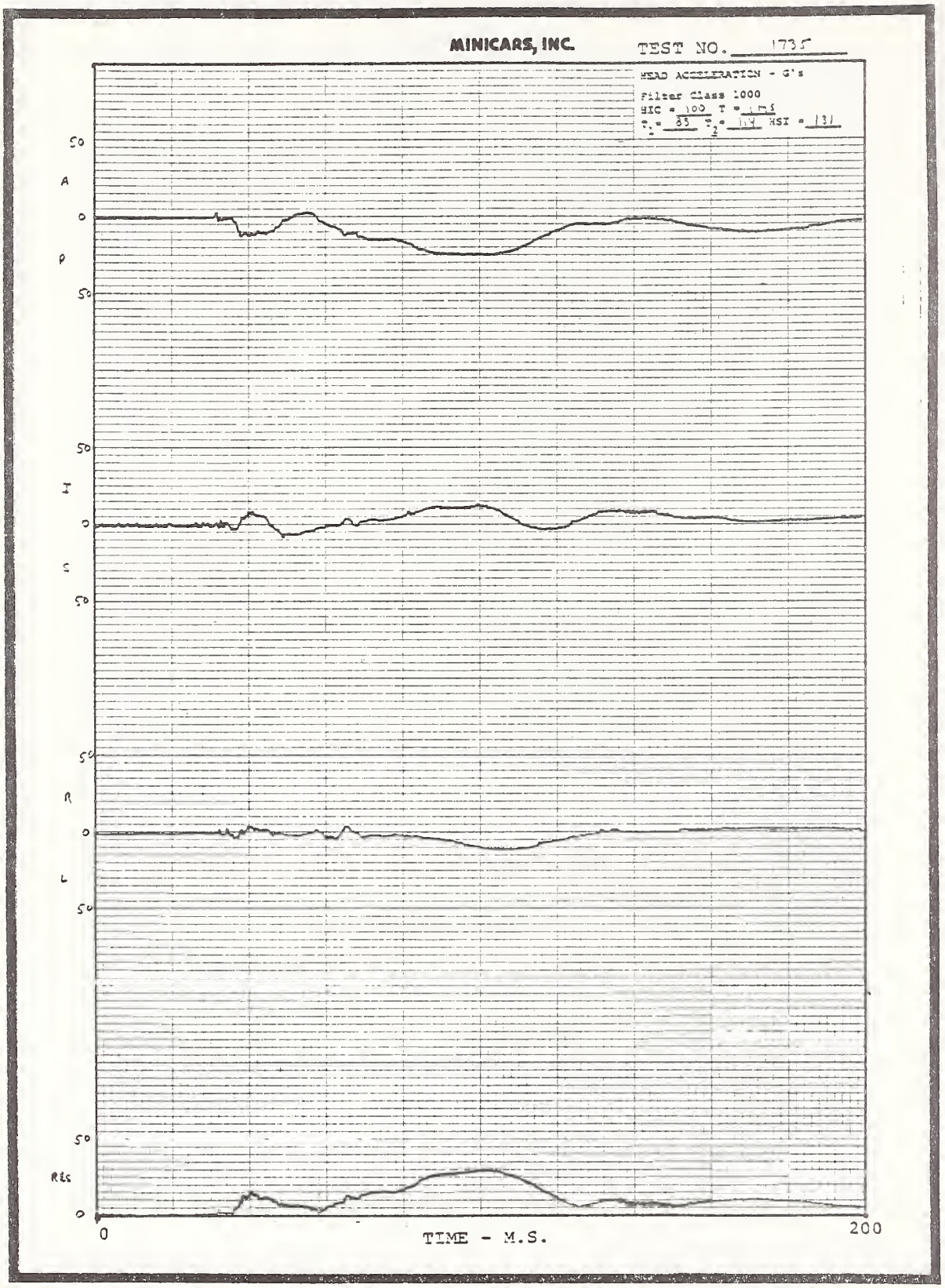

MINICARS, INC.
1718
RIGHT B PILLAR ACC
G's
F.C. 60
25
A
0
P
25
R
0
L
0
TIME - MS
200

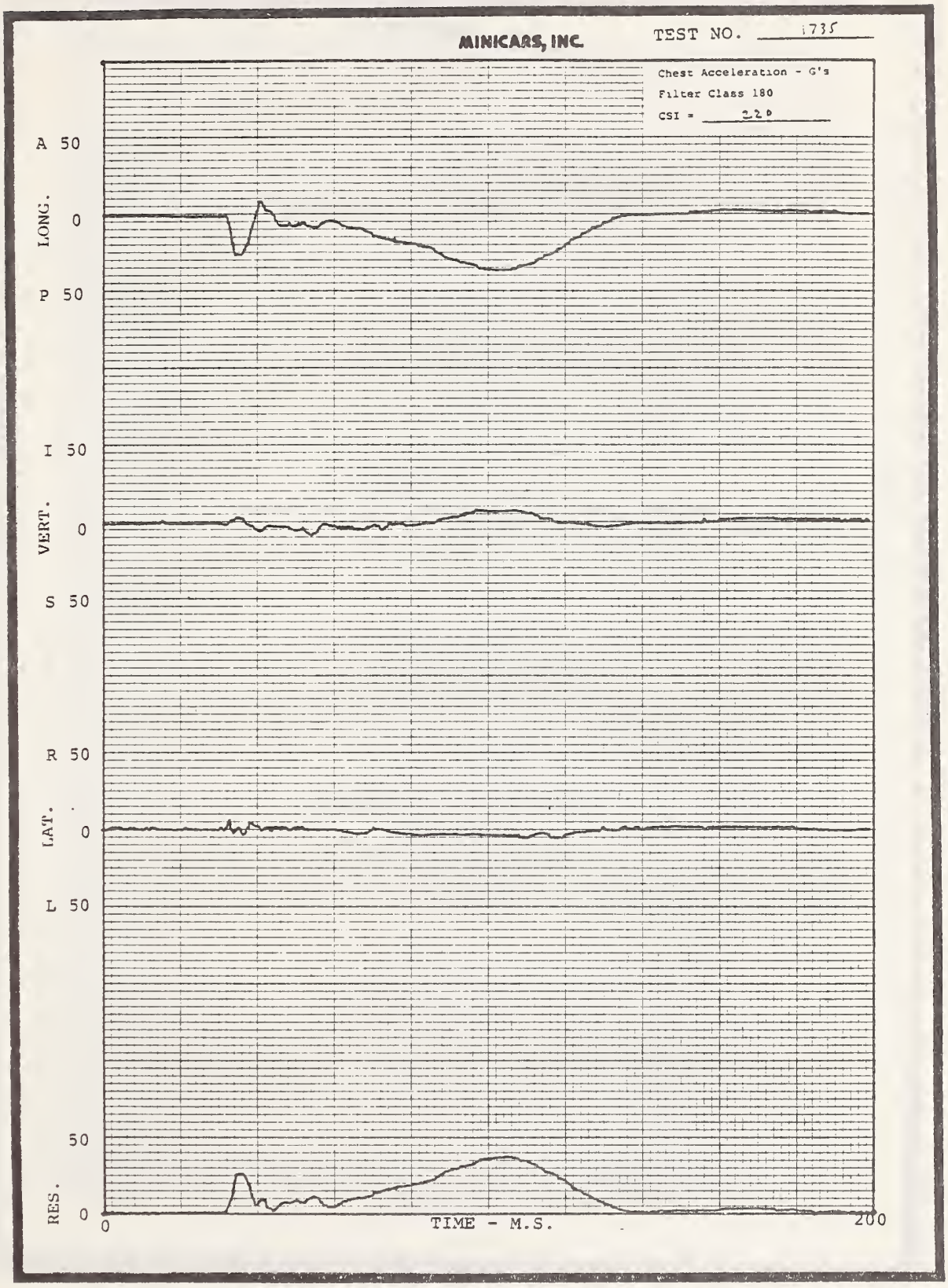

MINICARS, INC.
MID. TRUNK ACC. FC.60
1ST ∫
2ND ∫
FC.180
25
0
25
FPS
0
TIME - MS
200

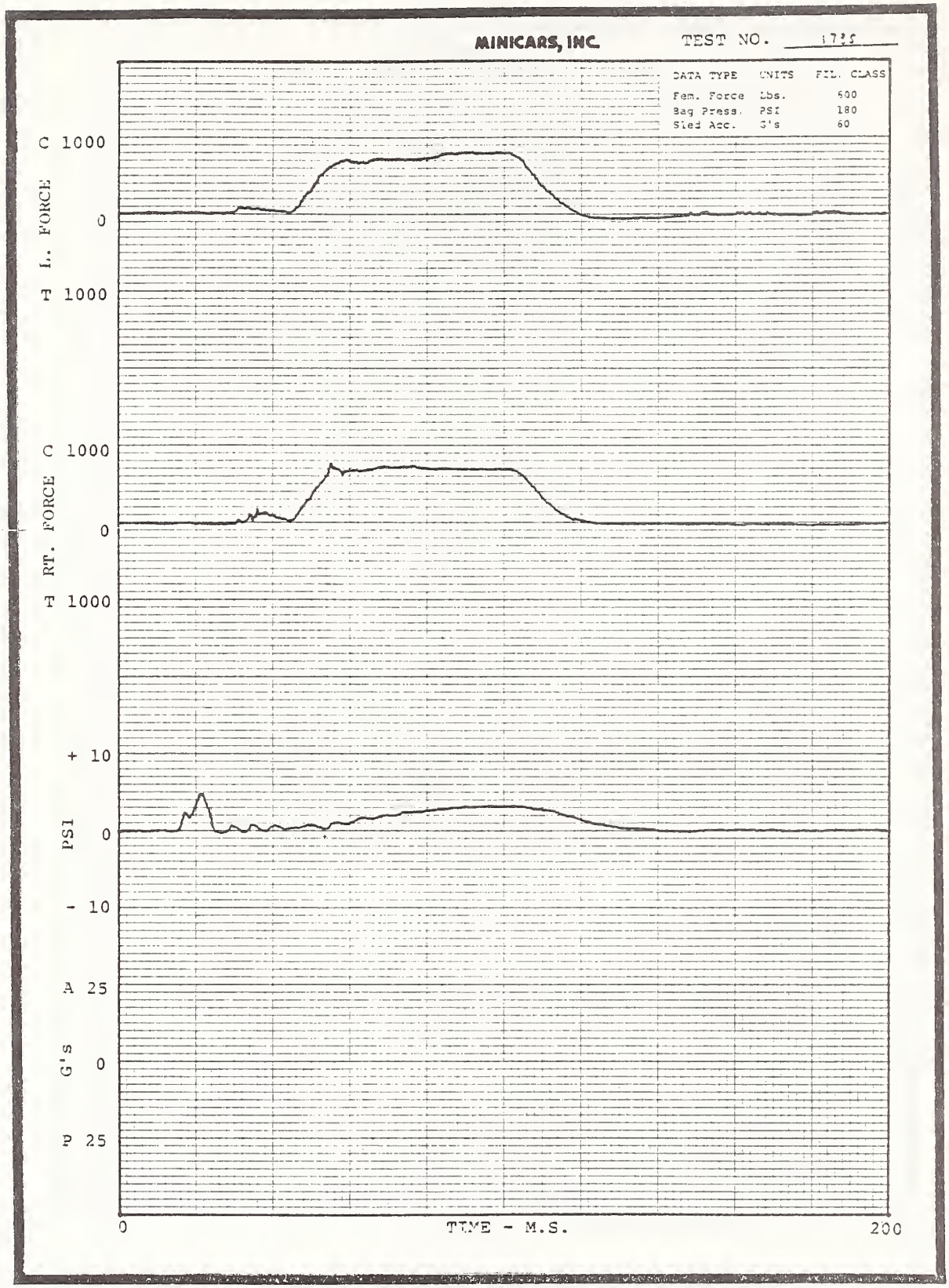

MINICARS, INC.
1718
MID TRUNK ACC. - G
F.C. 60
G
A
P
G
R
O
L
0
TIME - MS
200

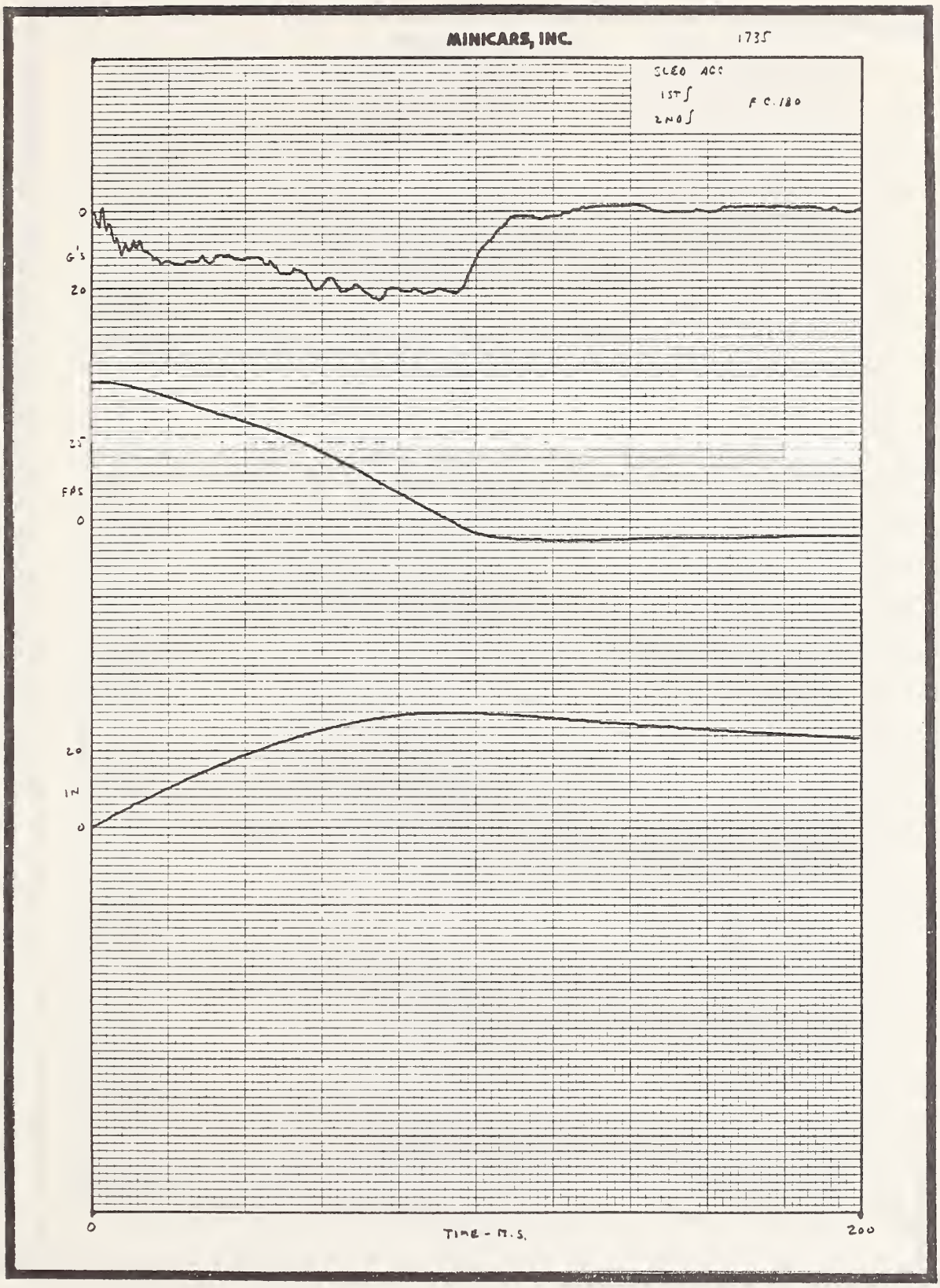

MINICARS, INC.
1716
0
TIME - MS
200

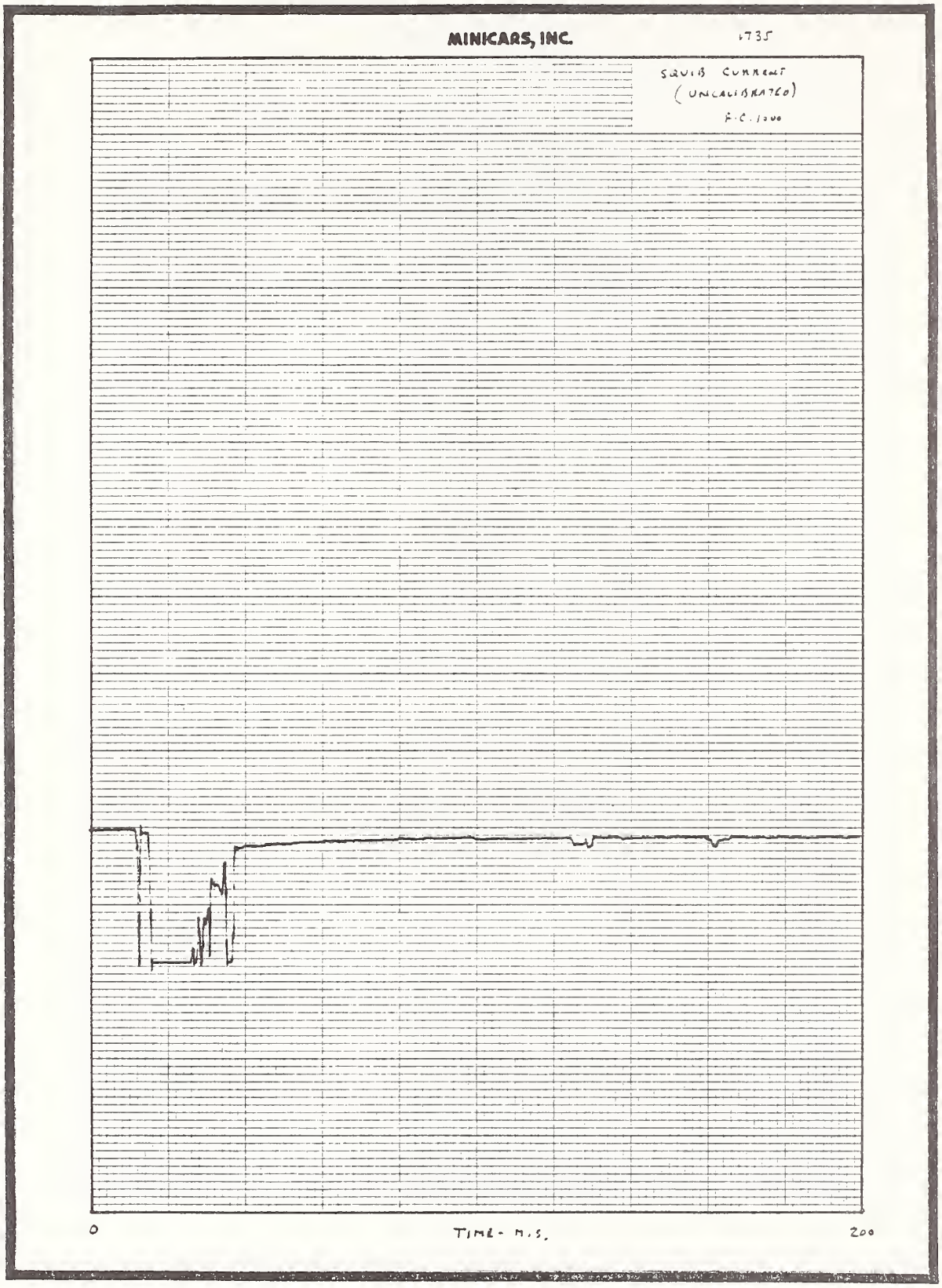

MINICARS, INC.
SAUIB CURRENT
(UNCALIBRATED)
0
TIME - MS
200


MINICARS, INC.
TEST NO. 1735
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 100 T = 1 MS
HSI = 131
50
A
0
P
50
50
I
0
S
50
50
R
0
L
50
50
Res
0
0
TIME - M.S.
200

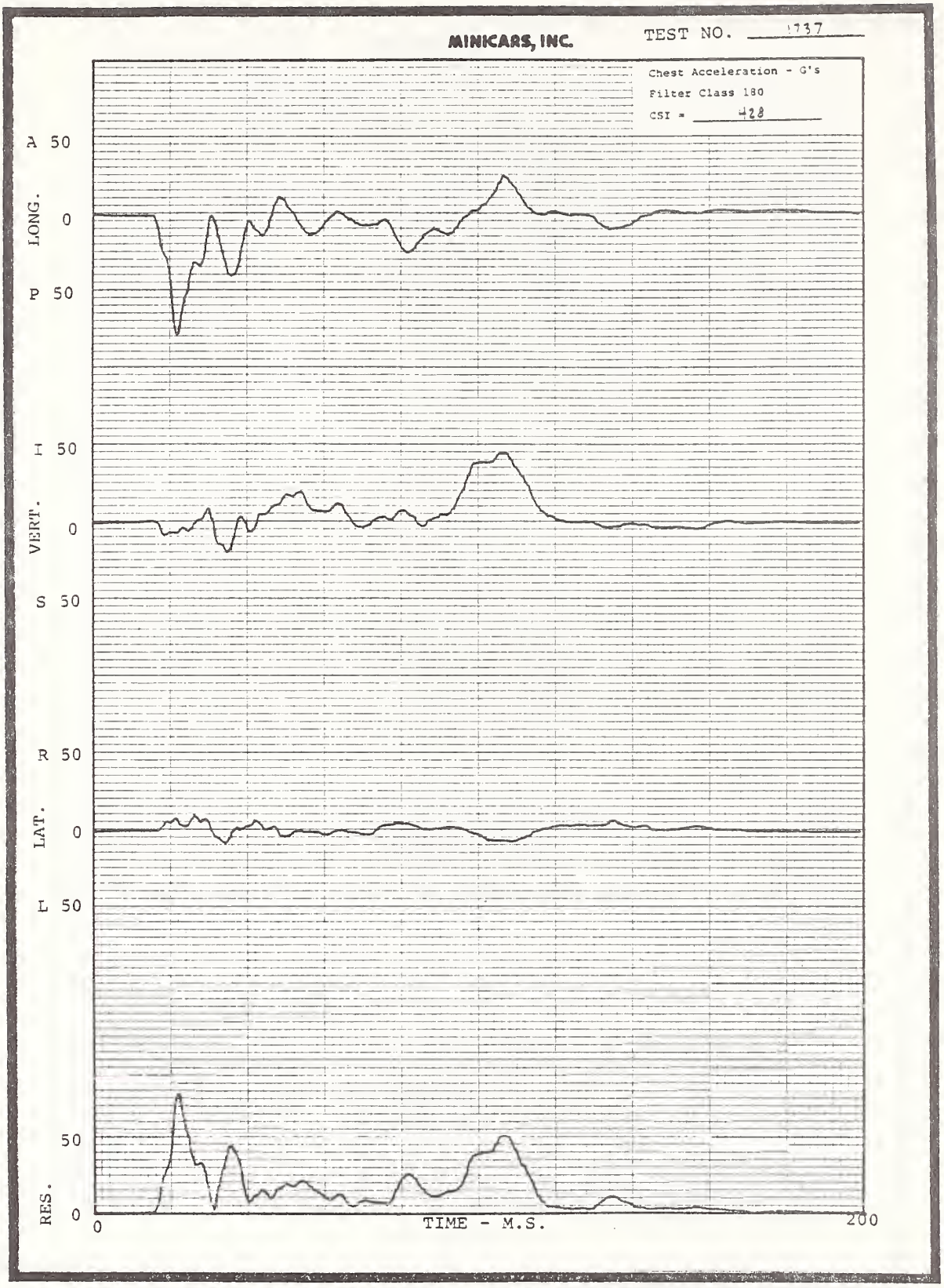

MINICARS, INC.
TEST NO. 1735
Chest Acceleration - G's
Filter Class 180
CSI = 220
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

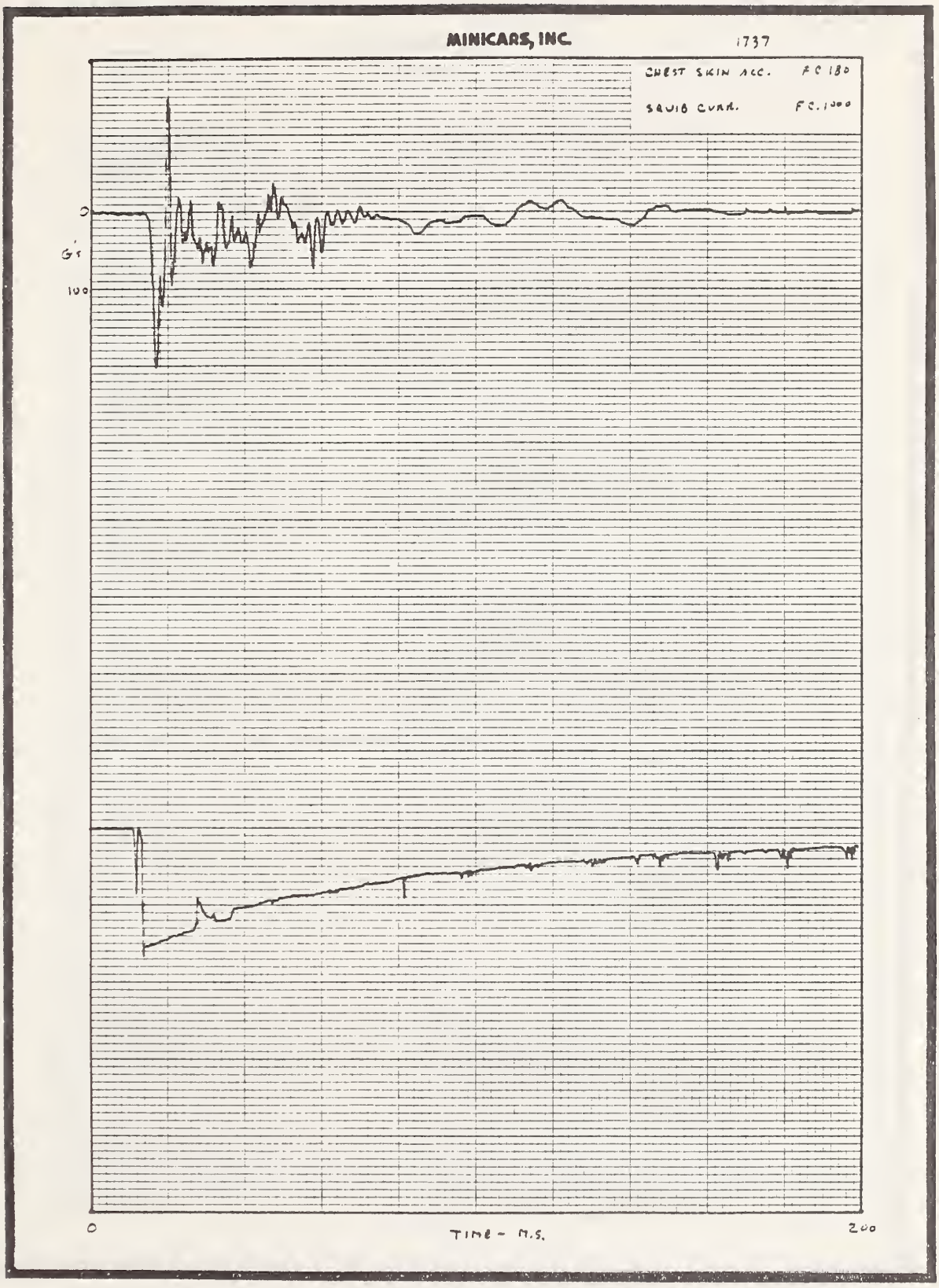

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
L. FORCE
0
T 1000
C 1000
RT. FORCE
0
T 1000
+ 10
PSI
0
- 10
A 25
G's
0
D 25
0
TIME - M.S.
200

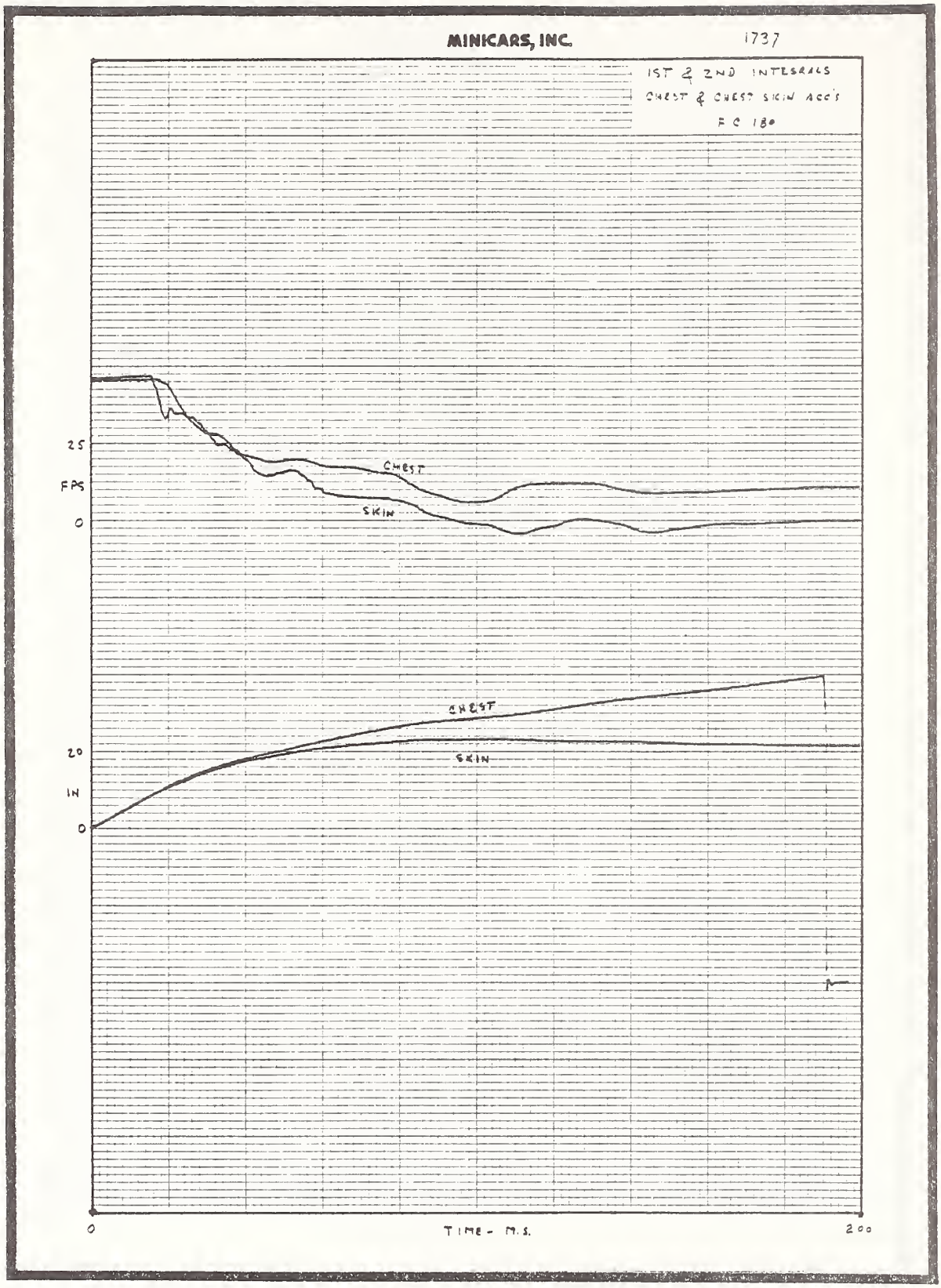

MINICARS, INC.
1735
SLED ACC
1ST ∫
2ND ∫
F C.180
0
G'S
20
20
FØS
0
20
IN
0
0
TIME - M.S.
200

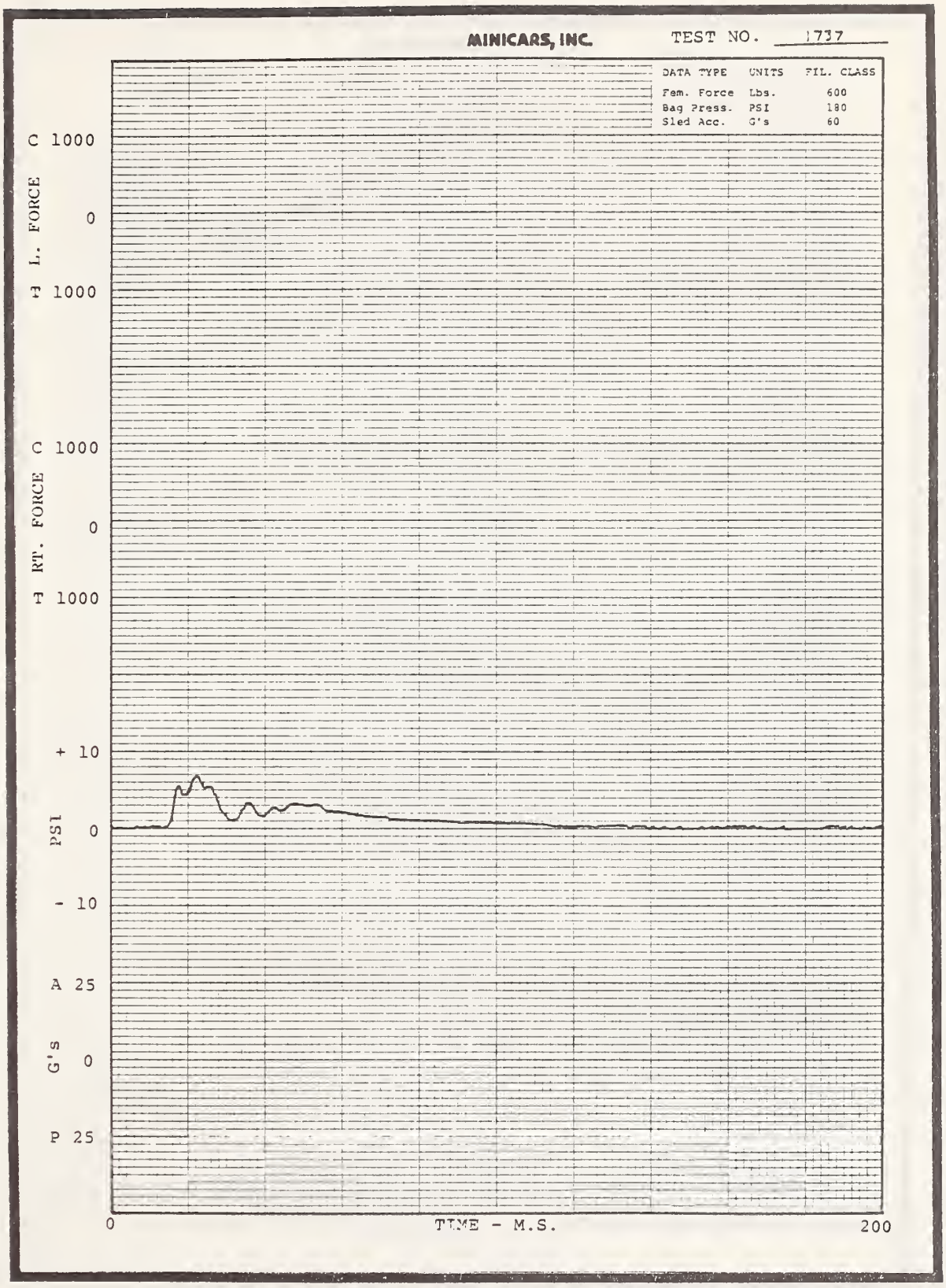

MINICARS, INC.
1735
SQUIB CURRENT
(UNCALIBRATED)
F.C. 1000
0
TIME - M.S.
200

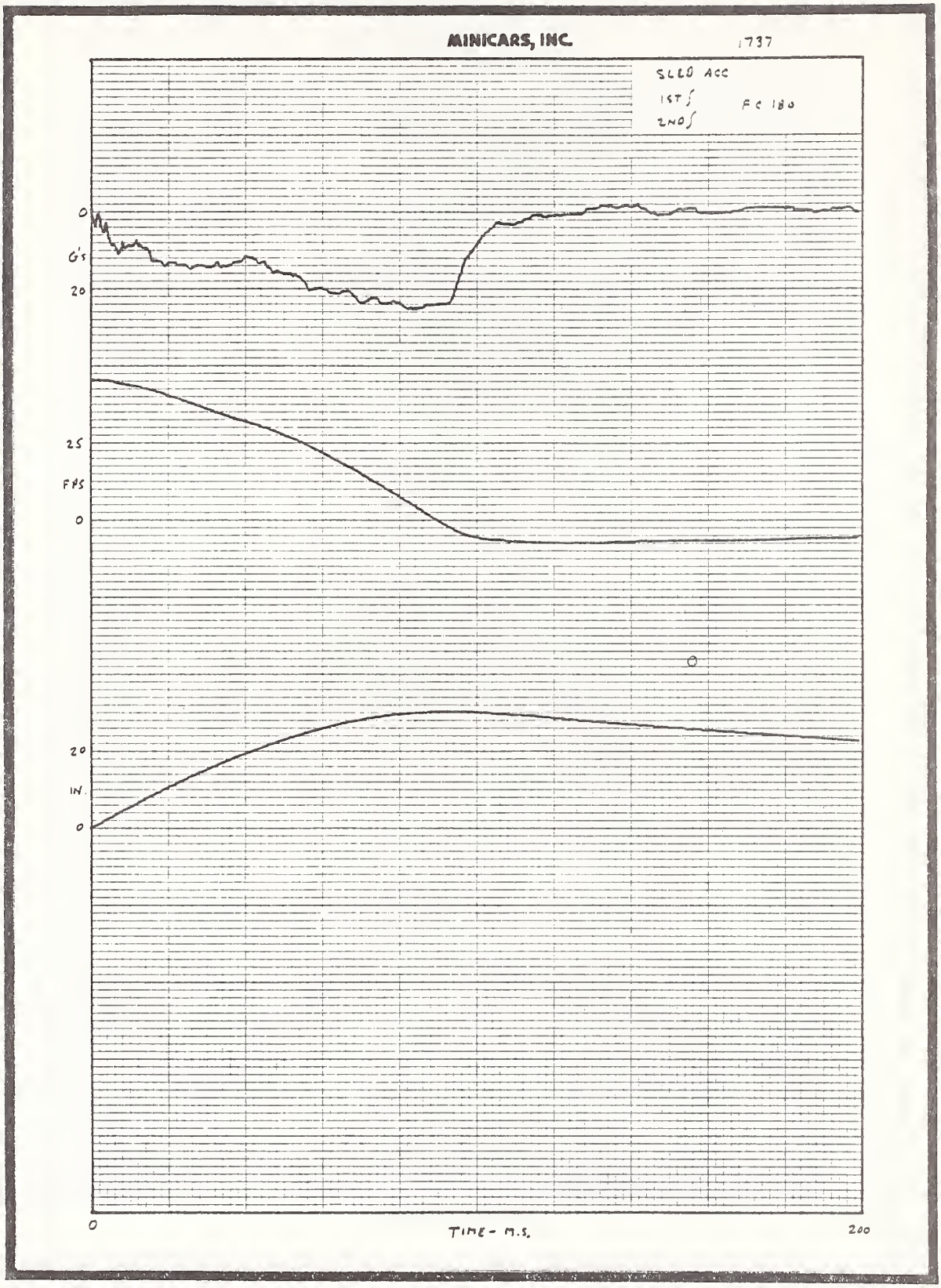
MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 307
ASI = 581
100
A
0
P
100
100
I
0
S
100
100
R
0
L
100
100
RES
0
0
TIME - M.S.
200

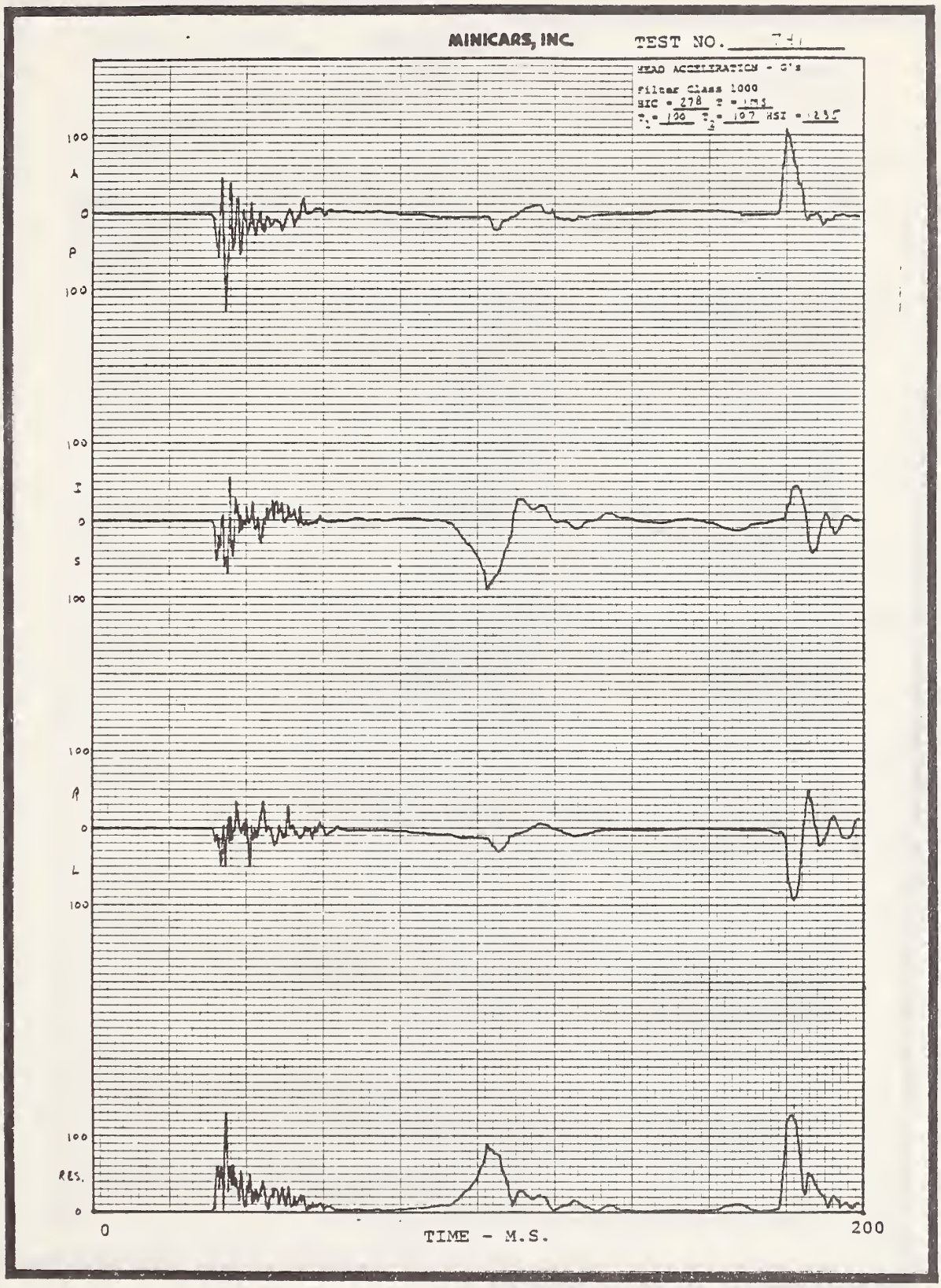

MINICARS, INC.
TEST NO. 1737
Chest Acceleration - G's
Filter Class 180
CSI = 428
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

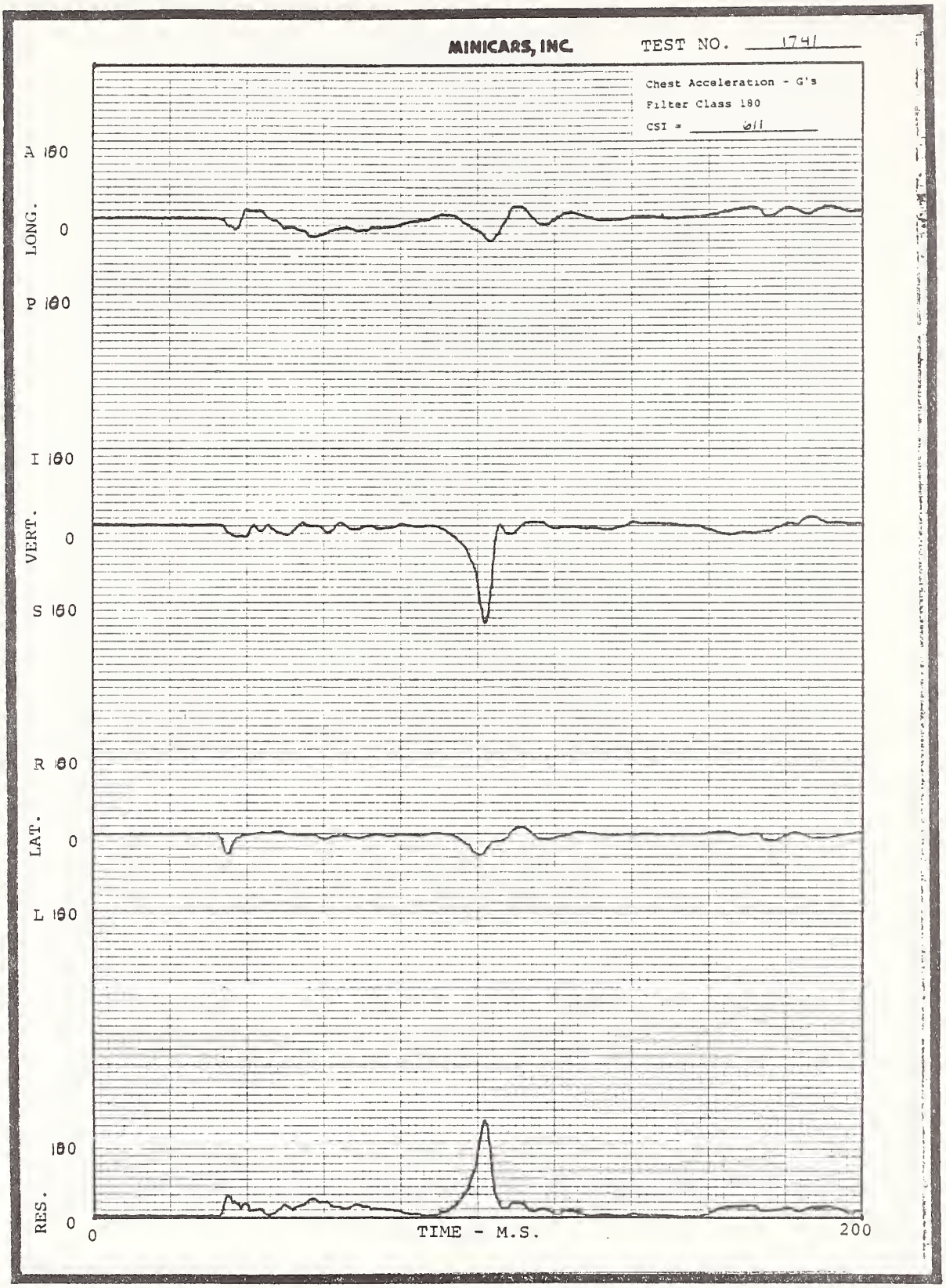

MINICARS, INC.
1737
CHEST SKIN ACC.
FC 180
SQUIB CURR.
FC. 1000
0
G's
100
0
TIME - M.S.
200

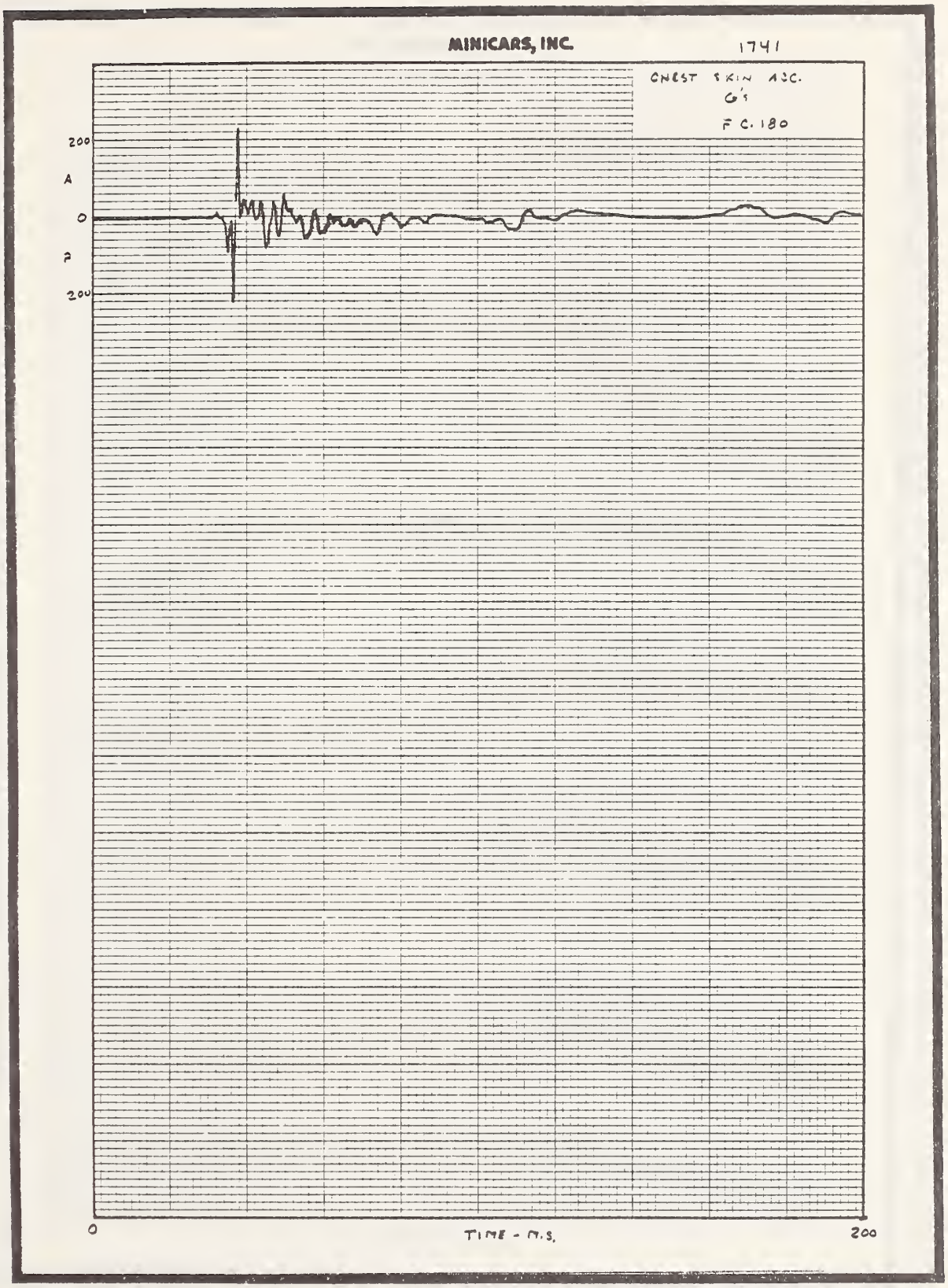

MINICARS, INC.
1737
1ST & 2ND INTEGRALS
CHEST & CHEST SKIN ACC'S
F C 180
25
FPS
0
CHEST
SKIN
CHEST
SKIN
20
IN
0
0
TIME - M.S.
200

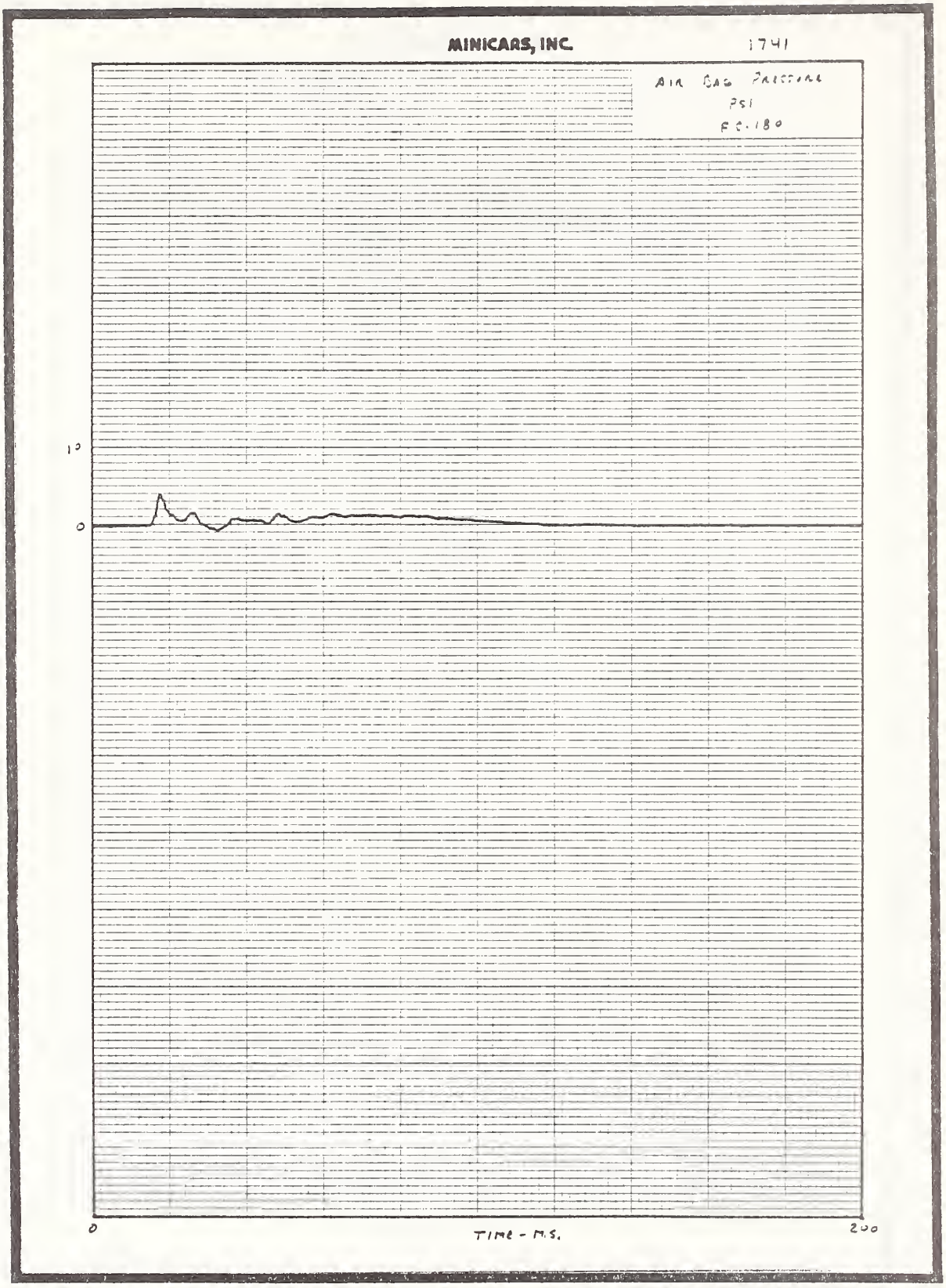

MINICARS, INC.
TEST NO. 1737
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
L. FORCE
0
T 1000
C 1000
RT. FORCE
0
T 1000
+ 10
PSI
0
- 10
A 25
G's
0
P 25
0
TIME - M.S.
200

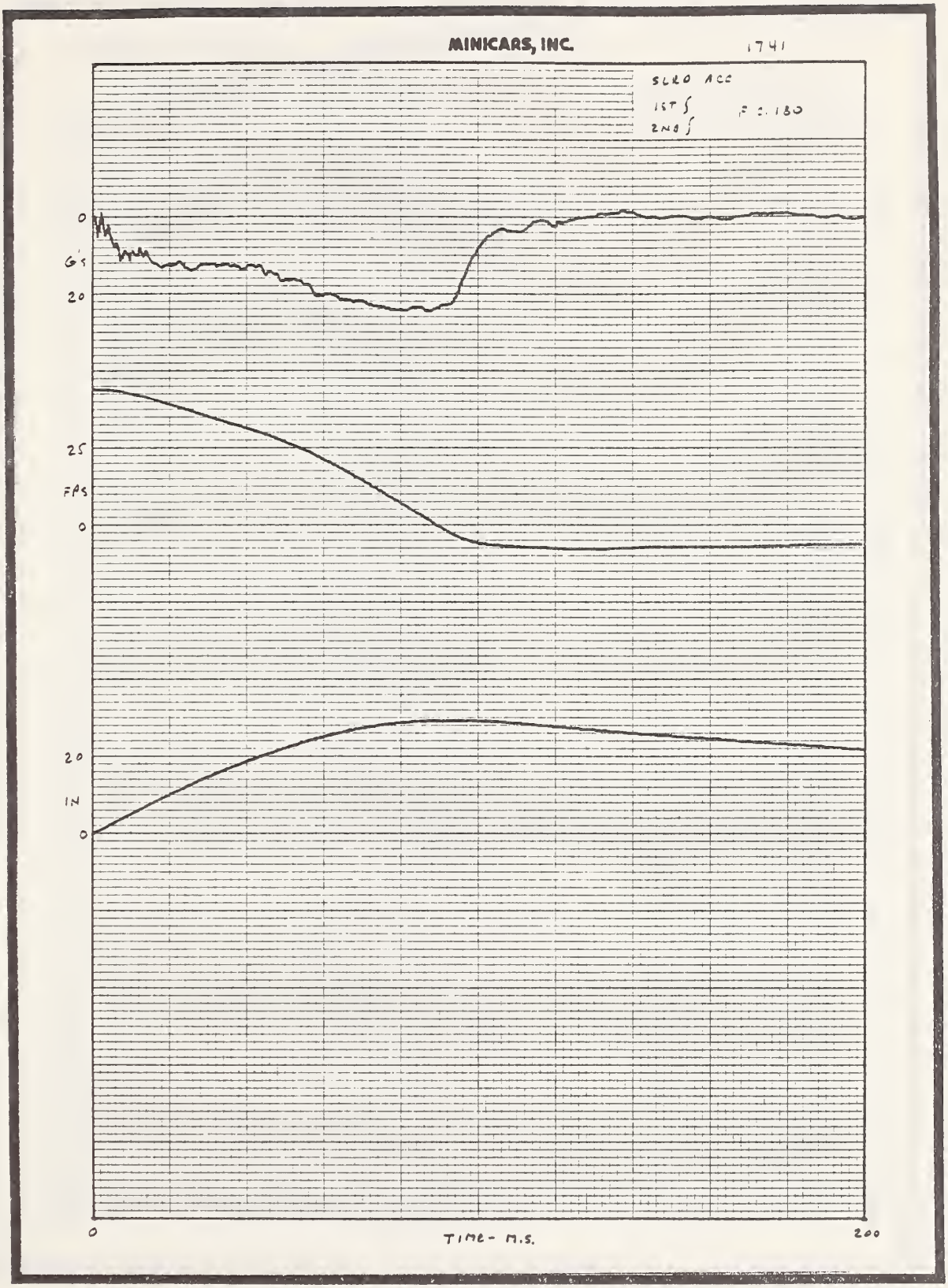

MINICARS, INC.
1737
SLED ACC
1ST ∫
2ND ∫
FC 180
0
G's
20
25
FPS
0
20
IN.
0
0
TIME - M.S.
200

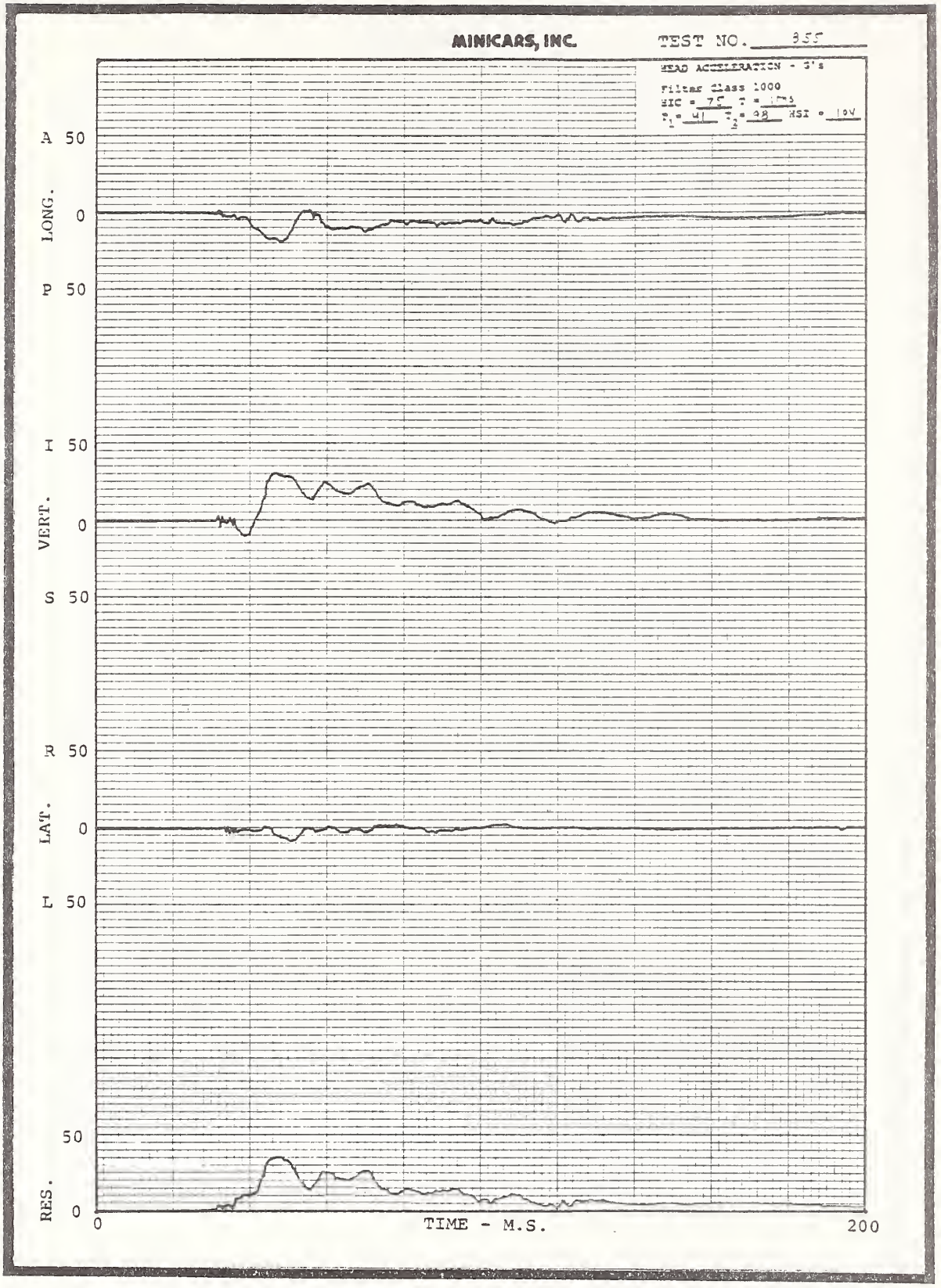

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 278
100
A
0
P
100
100
I
0
S
100
100
R
0
L
100
100
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
TEST NO. 1741
Chest Acceleration - G's
Filter Class 180
CSI = 611
A 180
LONG.
0
P 180
I 180
VERT.
0
S 180
R 180
LAT.
0
L 180
180
RES.
0
0
TIME - M.S.
200

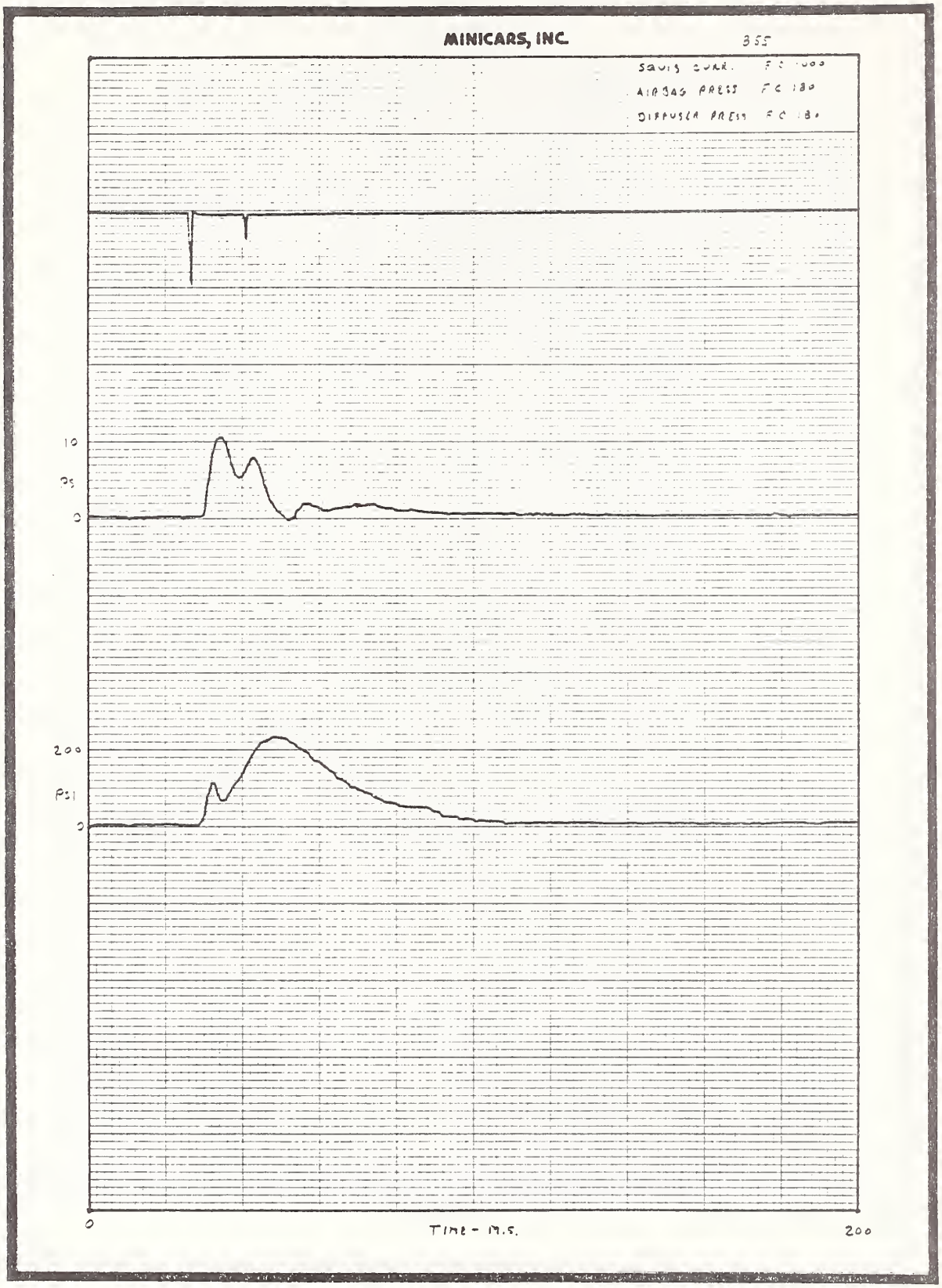

MINICARS, INC.
1741
CHEST SKIN ACC.
G's
F C. 180
200
A
0
P
200
0
TIME - M.S.
200

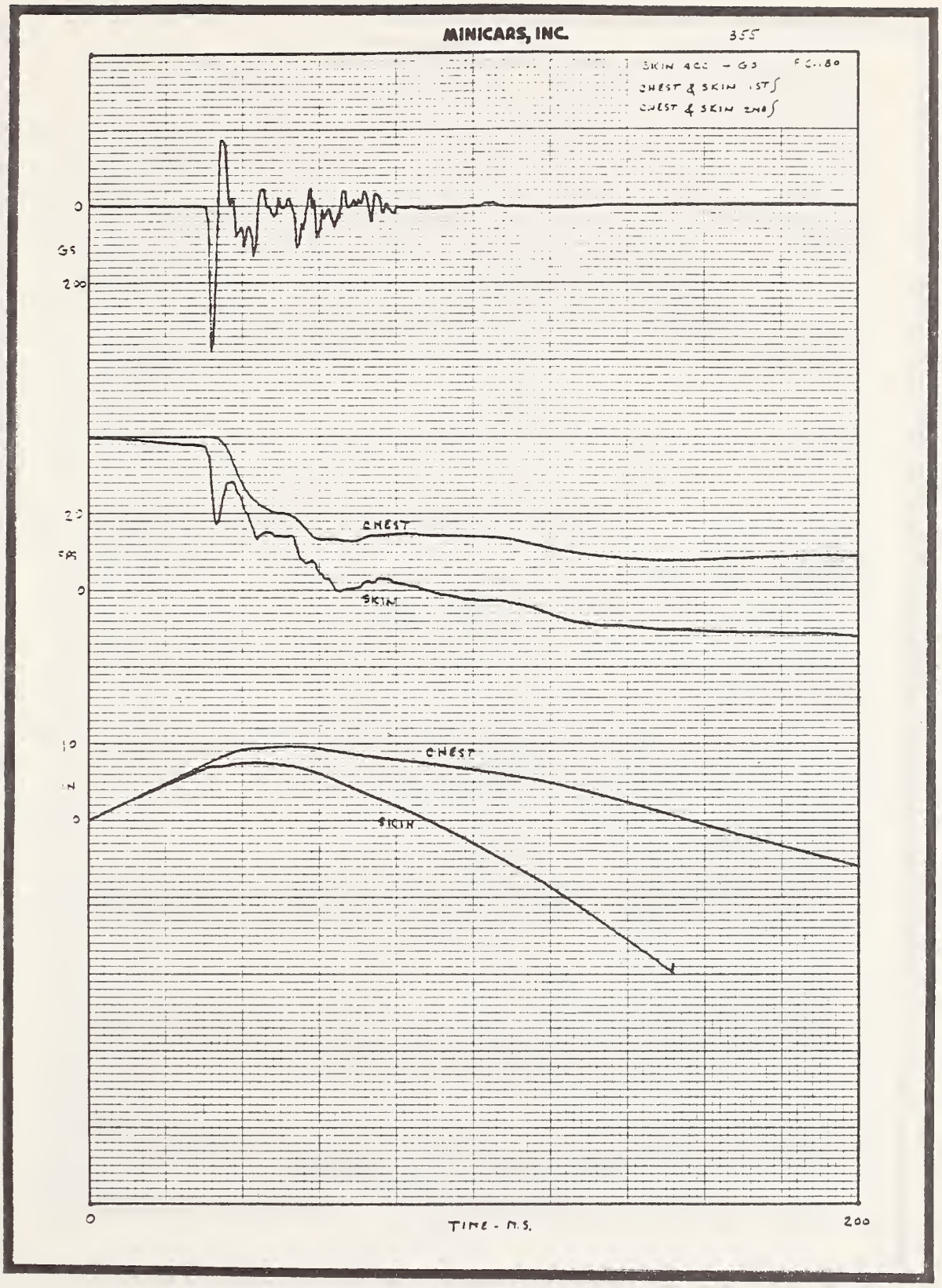

MINICARS, INC.
1741
AIR BAG PRESSURE
PSI
FC-180
10
0
0
TIME - M.S.
200

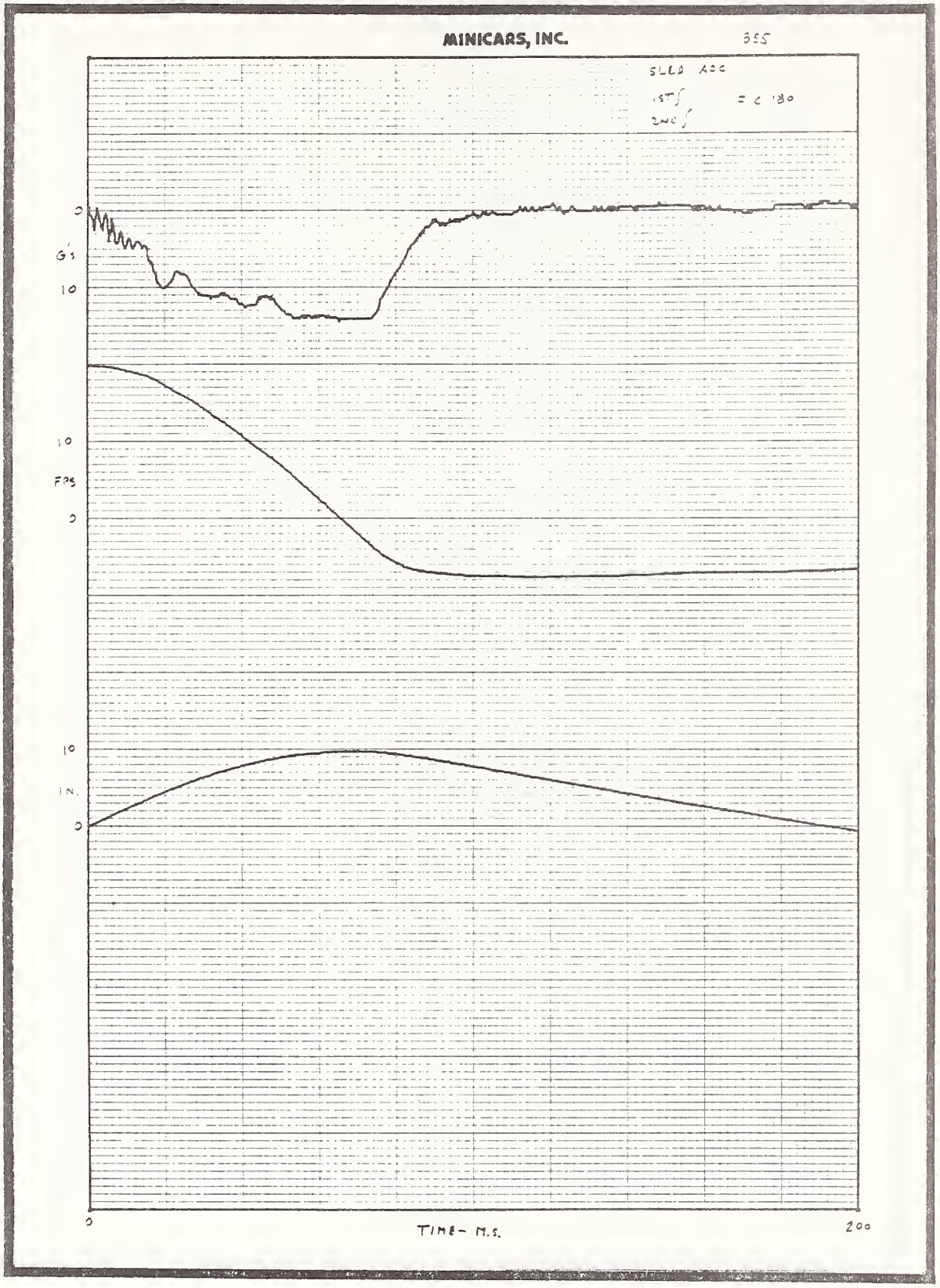

MINICARS, INC.
1741
SLED ACC
1ST ∫
2ND ∫
0
G's
20
25
FPS
0
20
IN
0
0
TIME - M.S.
200

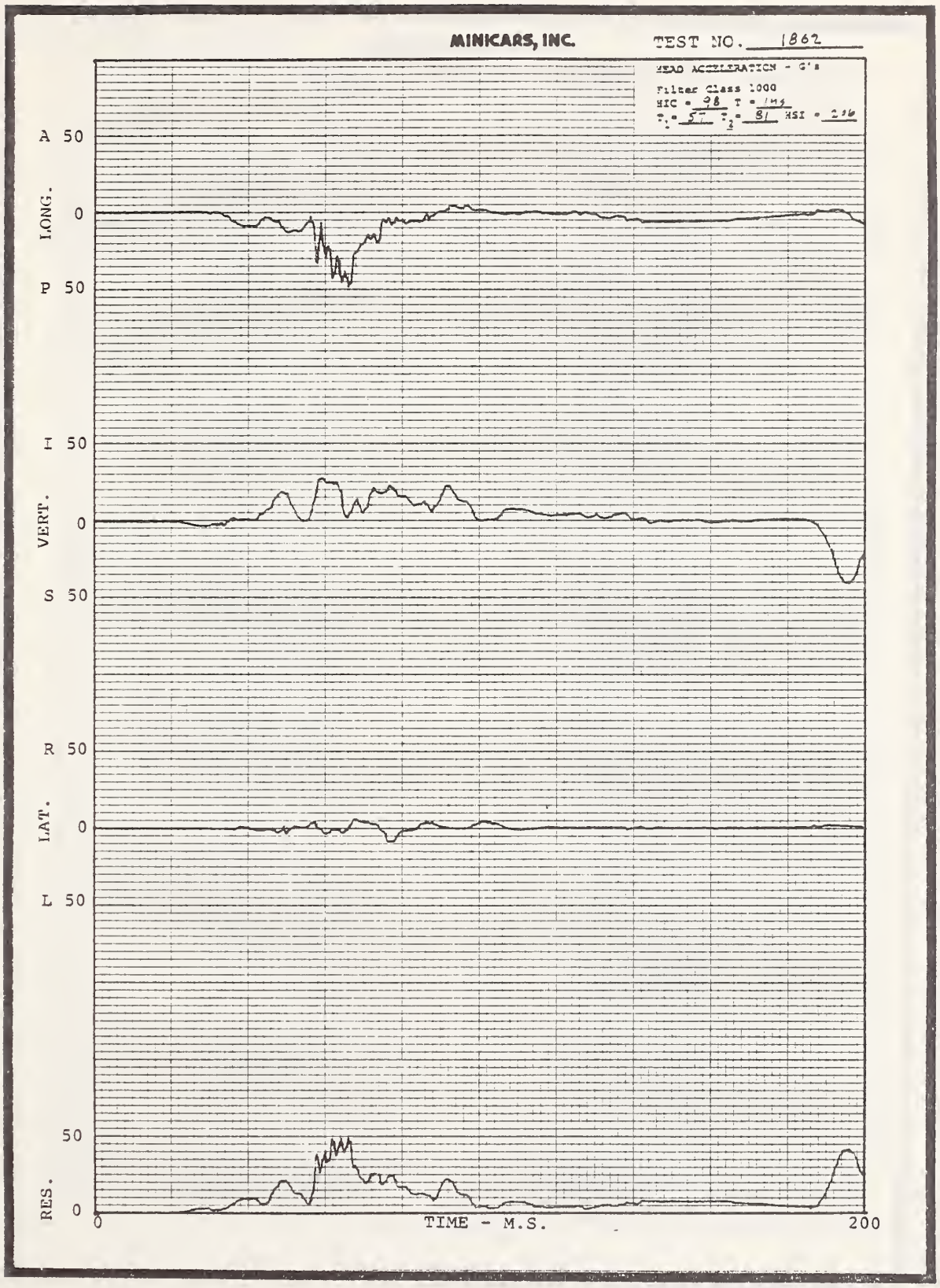

MINICARS, INC.
TEST NO.
HEAD ACCELERATION - G's
Filter Class 1000
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

MINICARS, INC.
TEST NO. 1855
Chest Acceleration - G's
Filter Class 180
CSI = 274
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

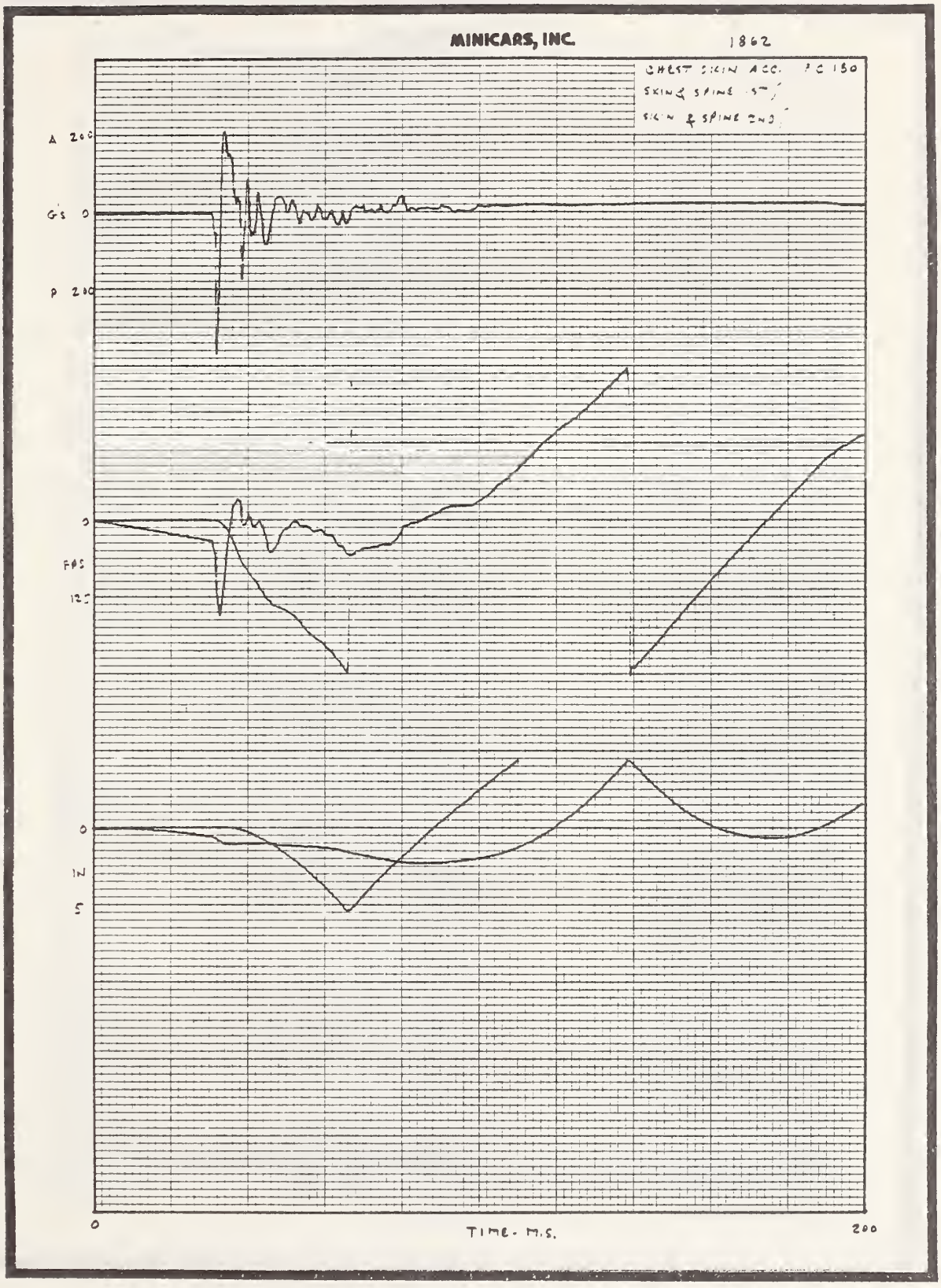

MINICARS, INC.
355
SQUIB CURR. FC 1000
AIRBAG PRESS FC 180
DIFFUSER PRESS FC 180
10
PSI
0
200
PSI
0
0
TIME - M.S.
200

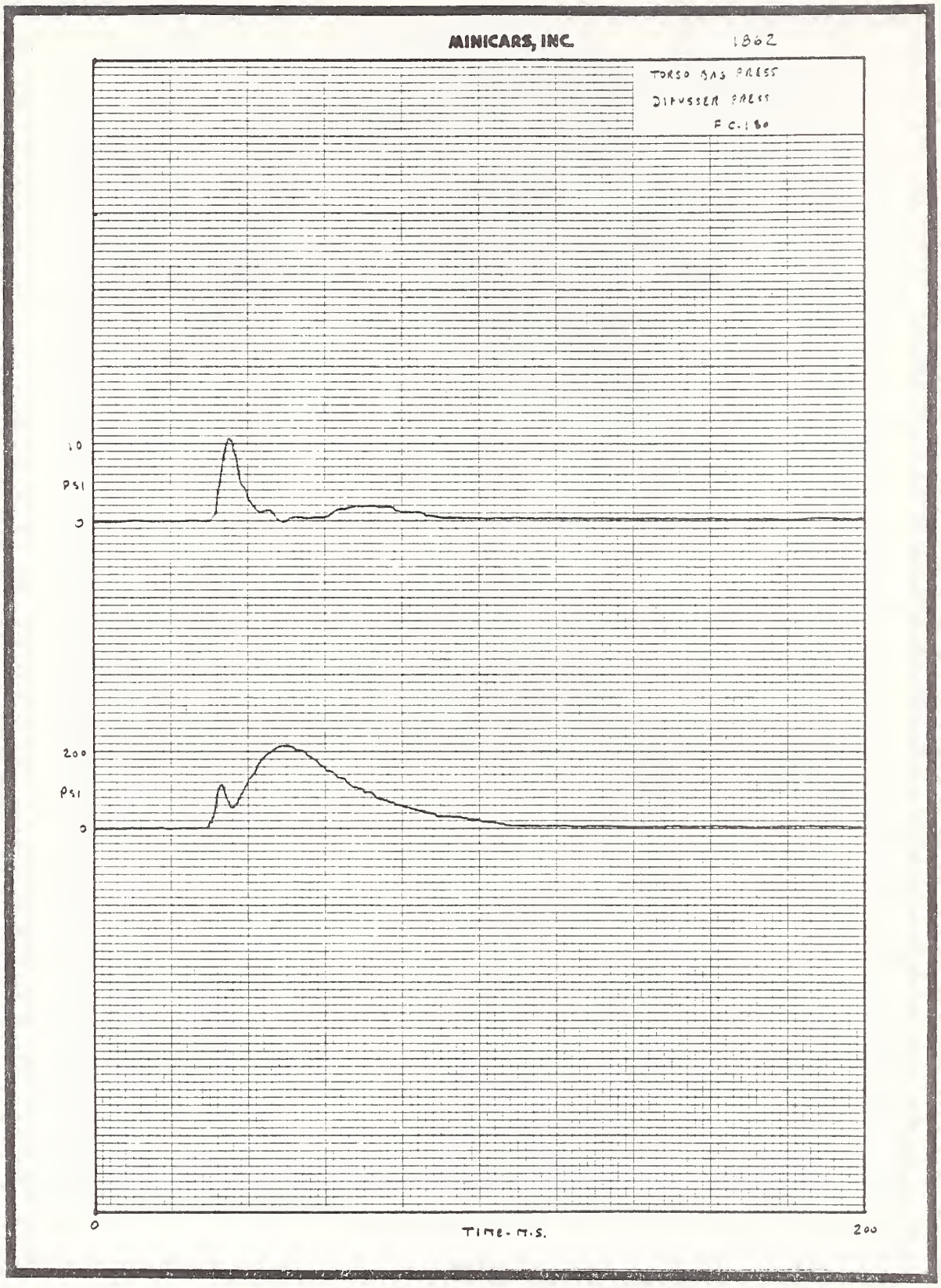

MINICARS, INC.
355
SKIN ACC - G'S
CHEST & SKIN 1ST
CHEST & SKIN 2ND
0
G'S
200
20
0
CHEST
SKIN
10
0
CHEST
SKIN
0
TIME - M.S.
200

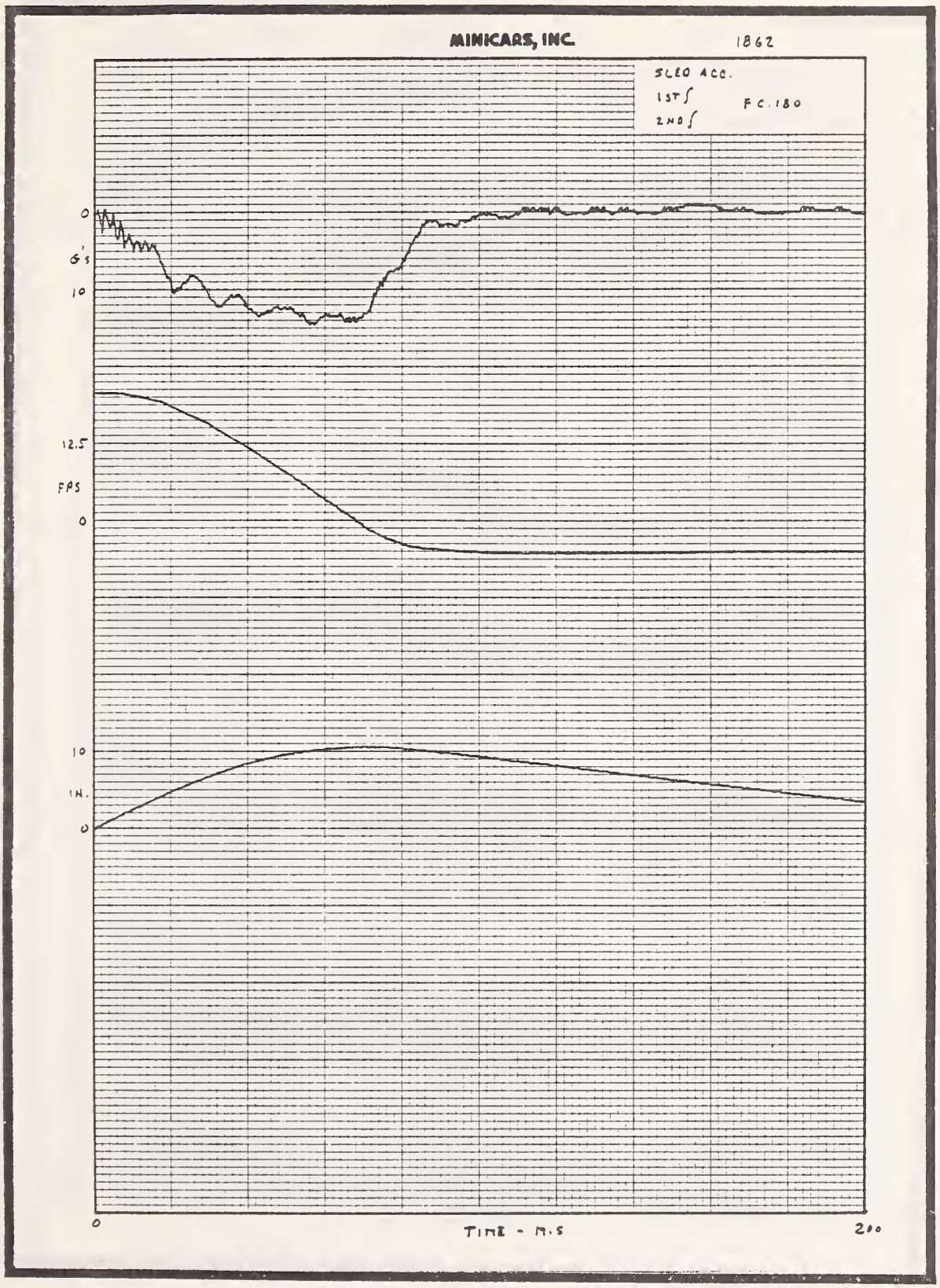

MINICARS, INC.
355
SLED ACC
1ST
2ND
= C 180
0
G's
10
10
FPS
0
10
IN.
0
0
TIME - M.S.
200

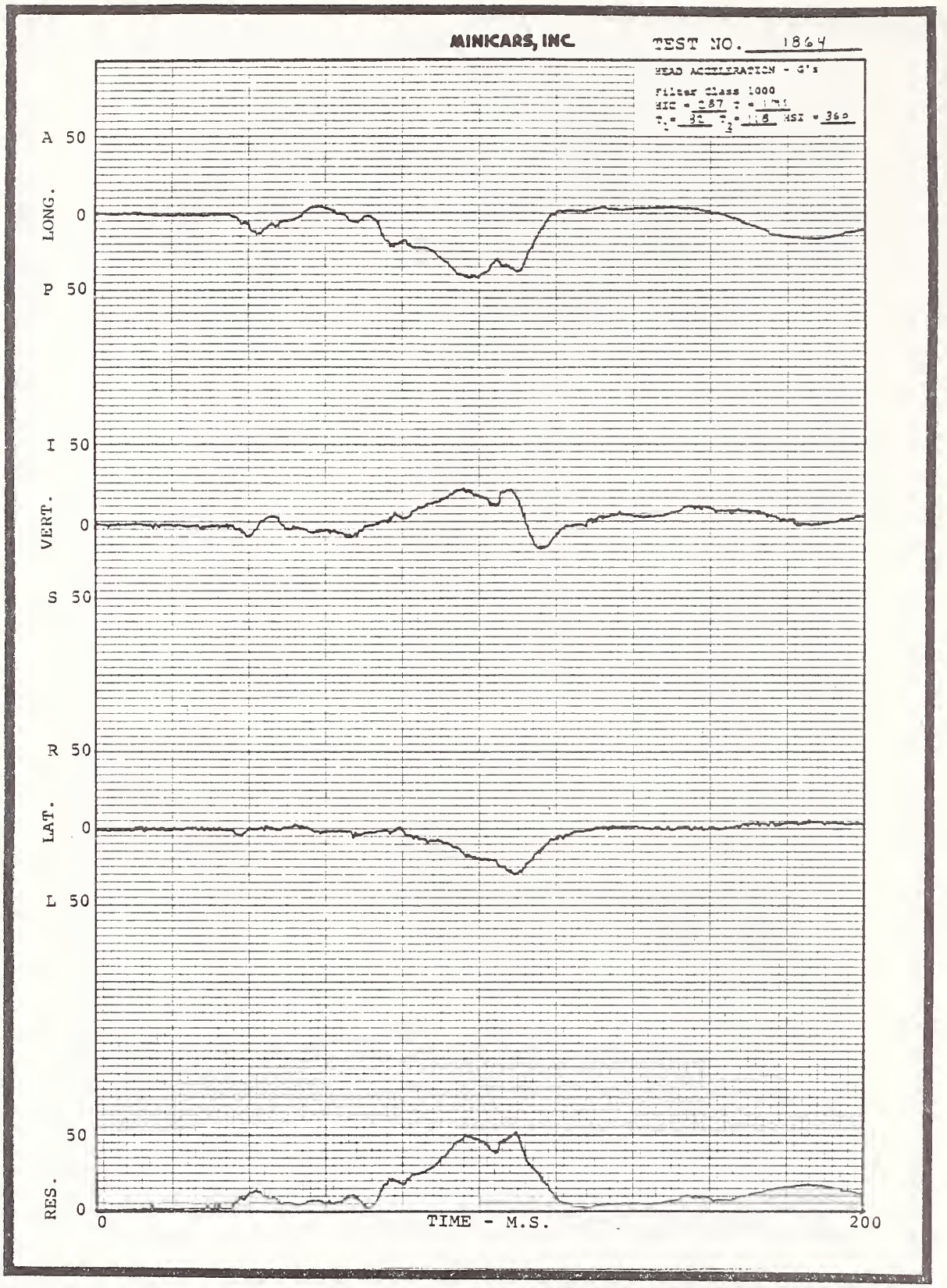

MINICARS, INC.
TEST NO. 1862
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 98 T = 1ms
T1 = 57 T2 = 81 HSI = 296
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

MINICARS, INC.
TEST NO. 962
Chest Acceleration - G's
Filter Class 180
CSI = 187
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

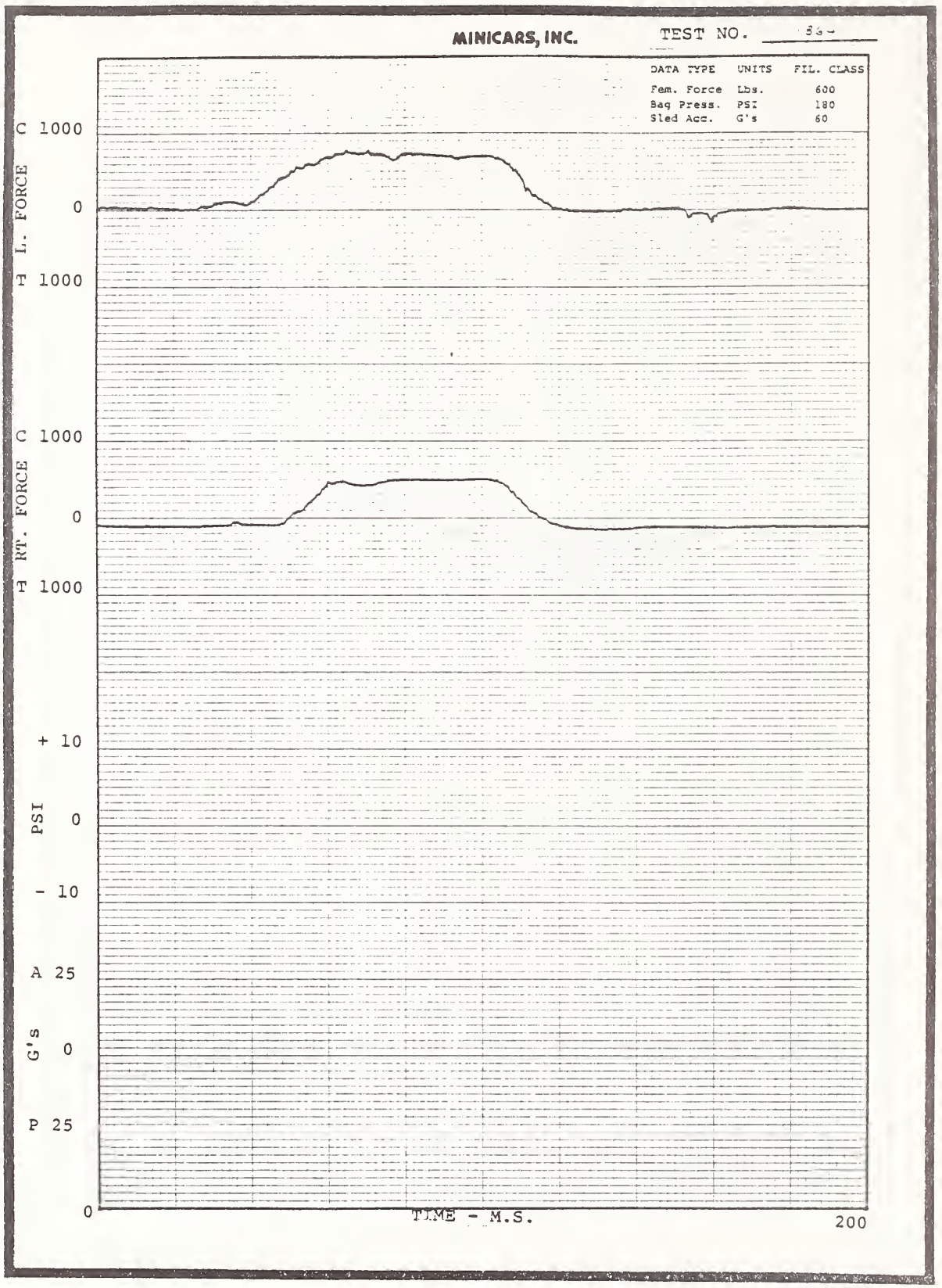

MINICARS, INC.
1862
CHEST SKIN ACC. PC 150
SKIN & SPINE 1ST
SKIN & SPINE 2ND
A 200
G's 0
P 200
0
FPS
125
0
IN
5
0
TIME - M.S.
200

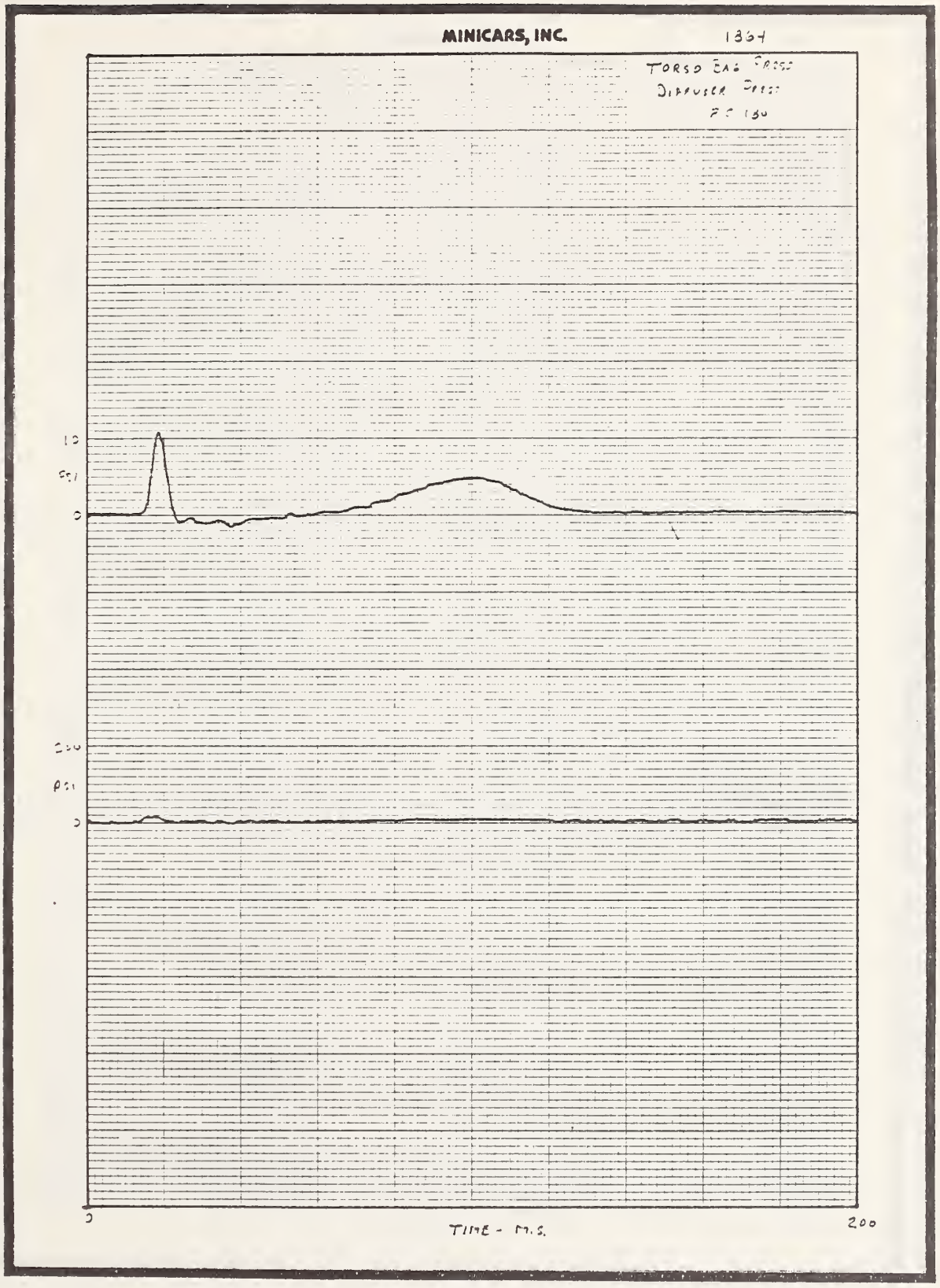

MINICARS, INC.
1862
TORSO BAG PRESS
DIFUSSER PRESS
F.C.180
10
PSI
0
200
PSI
0
0
TIME-M.S.
200

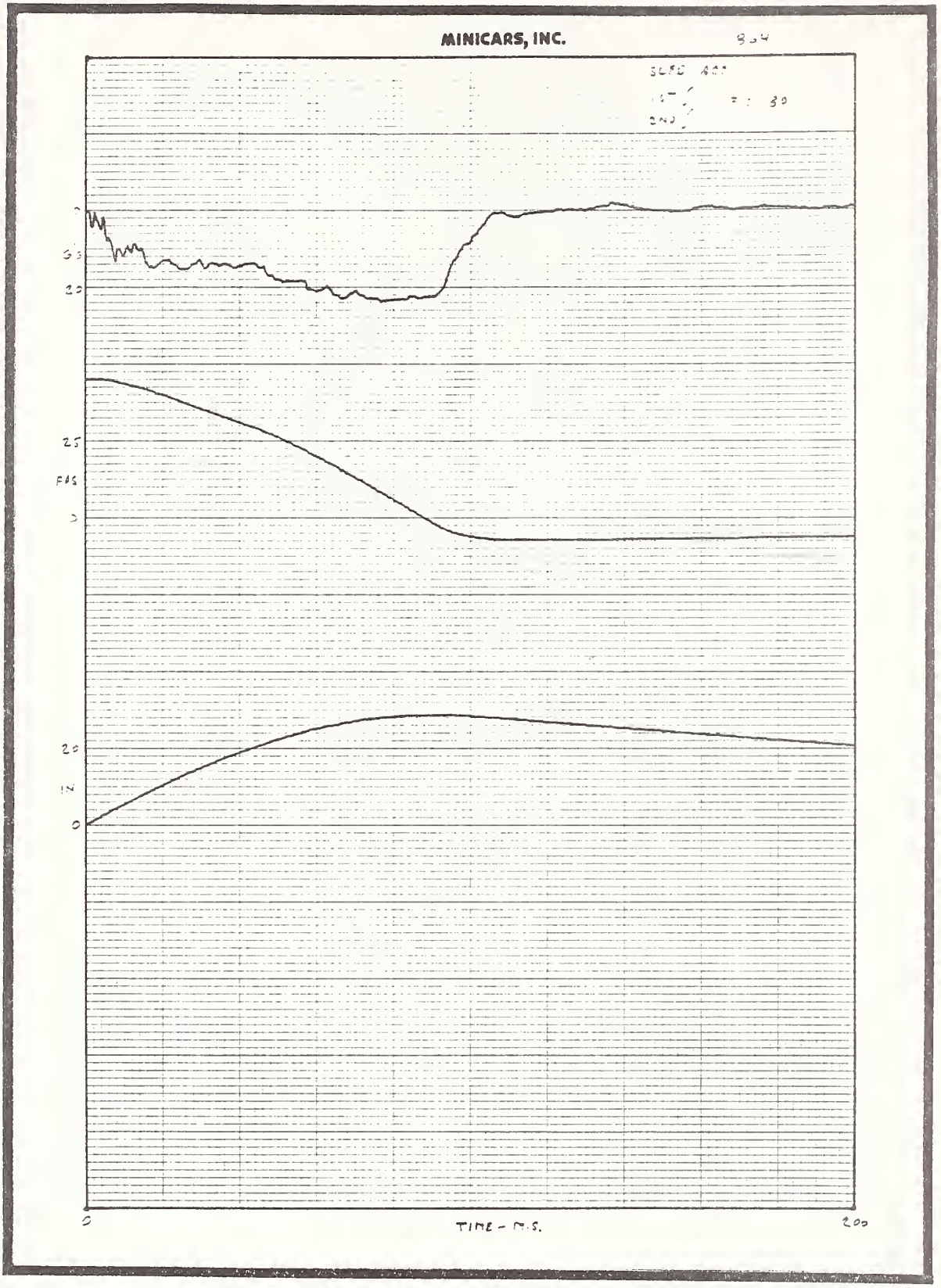

MINICARS, INC.
1862
SLED ACC.
1ST ∫
2ND ∫
F.C. 180
0
G'S
10
12.5
FPS
0
10
IN.
0
0
TIME - M.S
200

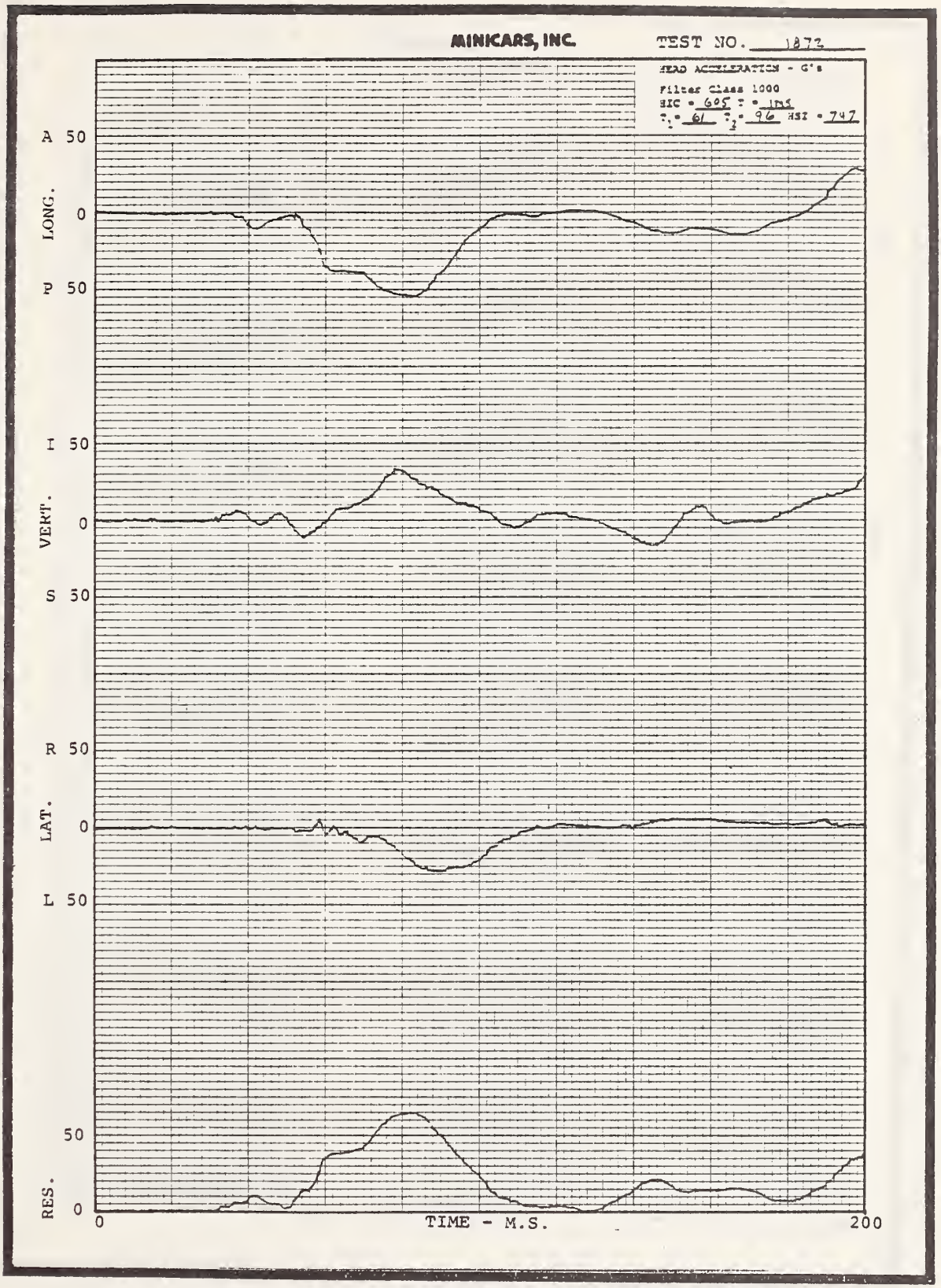

MINICARS, INC
TEST NO. 1864
HEAD ACCELERATION - G's
Filter Class 1000
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

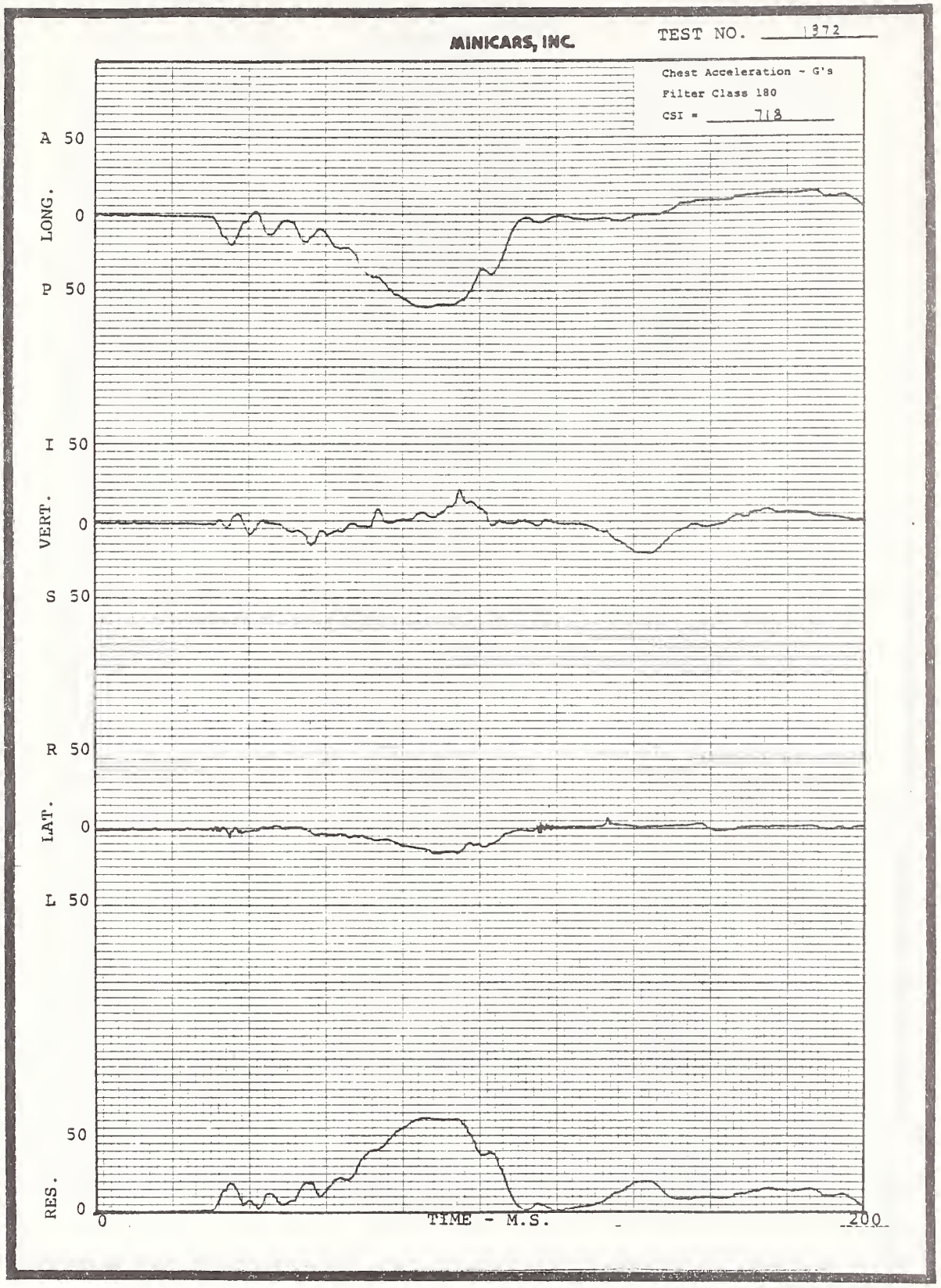
MINICARS, INC.
TEST NO. 1864
Chest Acceleration - G's
Filter Class 180
CSI = 308
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

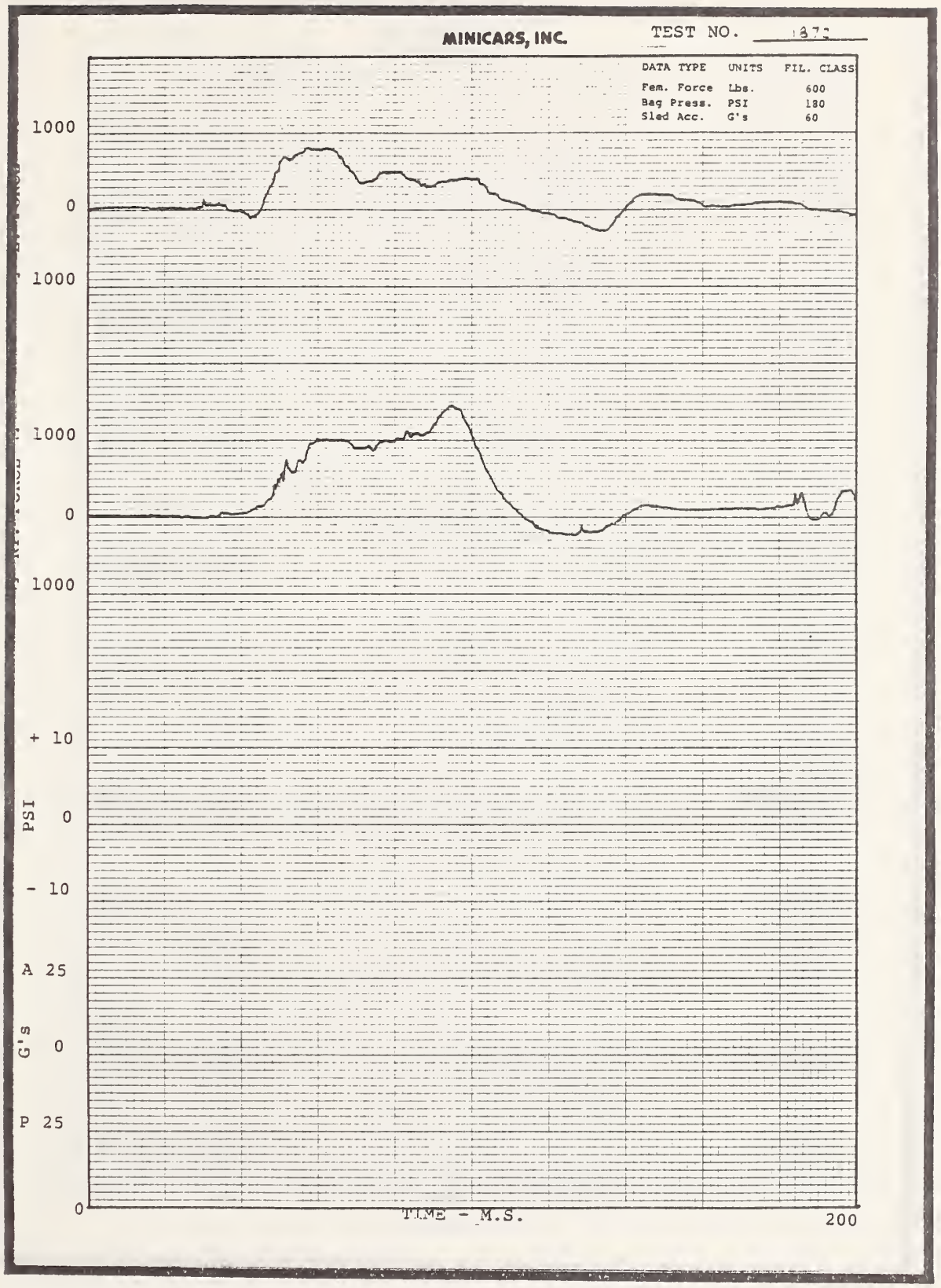

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
C 1000
0
T 1000
L. FORCE
C 1000
0
T 1000
RT. FORCE
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

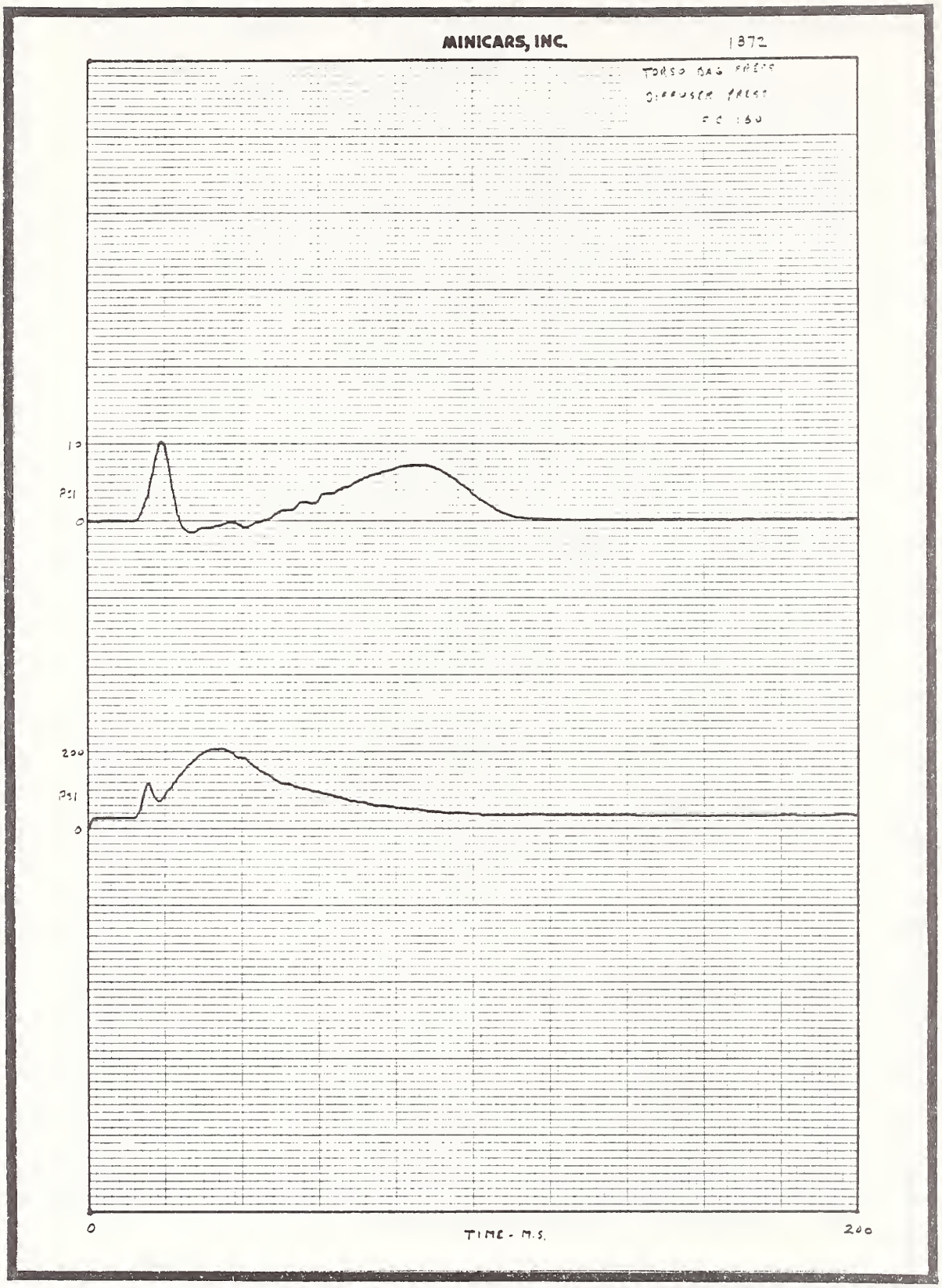

MINICARS, INC.
1364
TORSO BAG PRESS
DIFFUSER PRESS
PC 180
10
PSI
0
200
PSI
0
0
TIME - M.S.
200

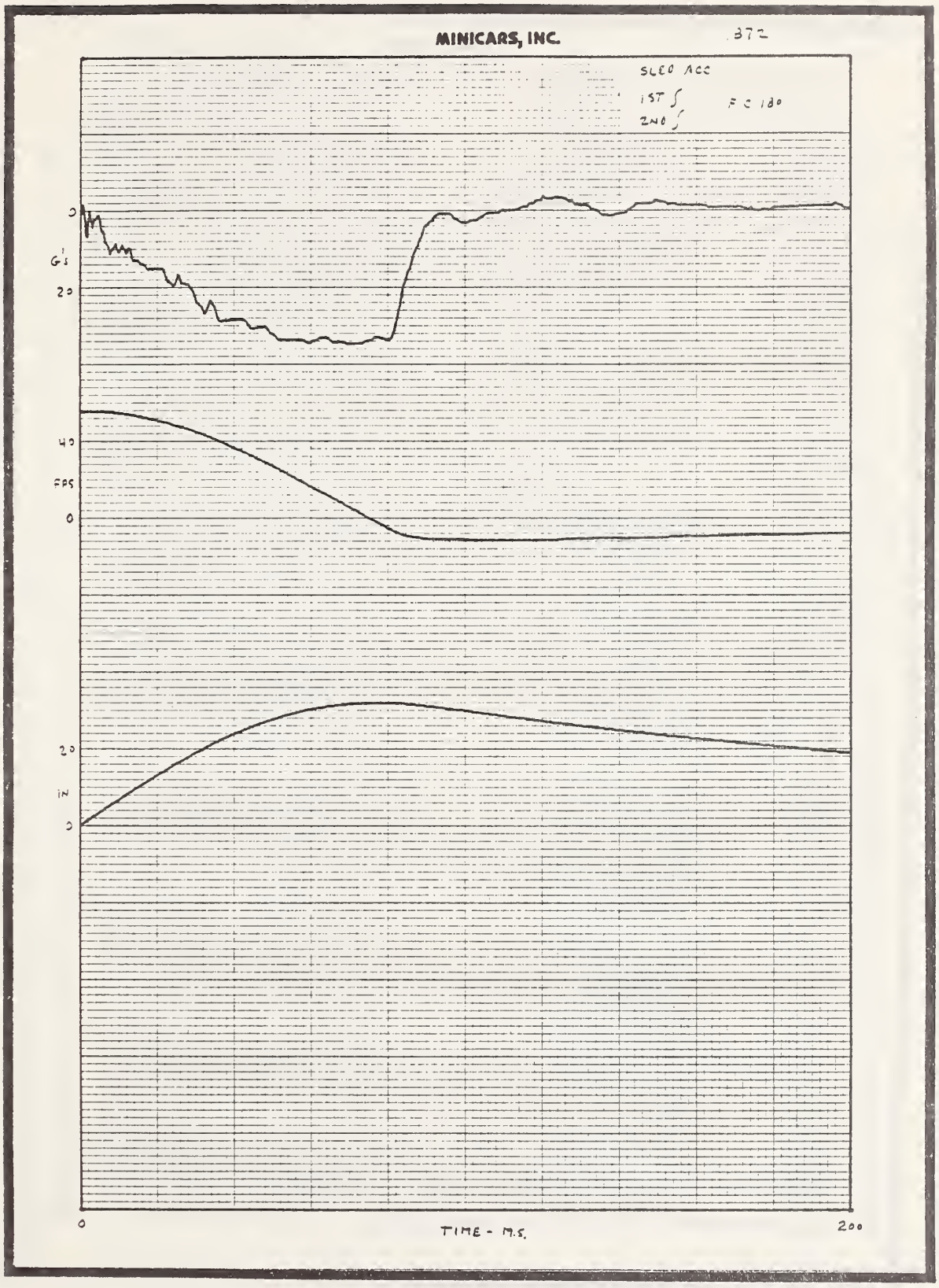

MINICARS, INC.
0
G's
30
25
FPS
0
20
IN
0
0
TIME - M.S.
200

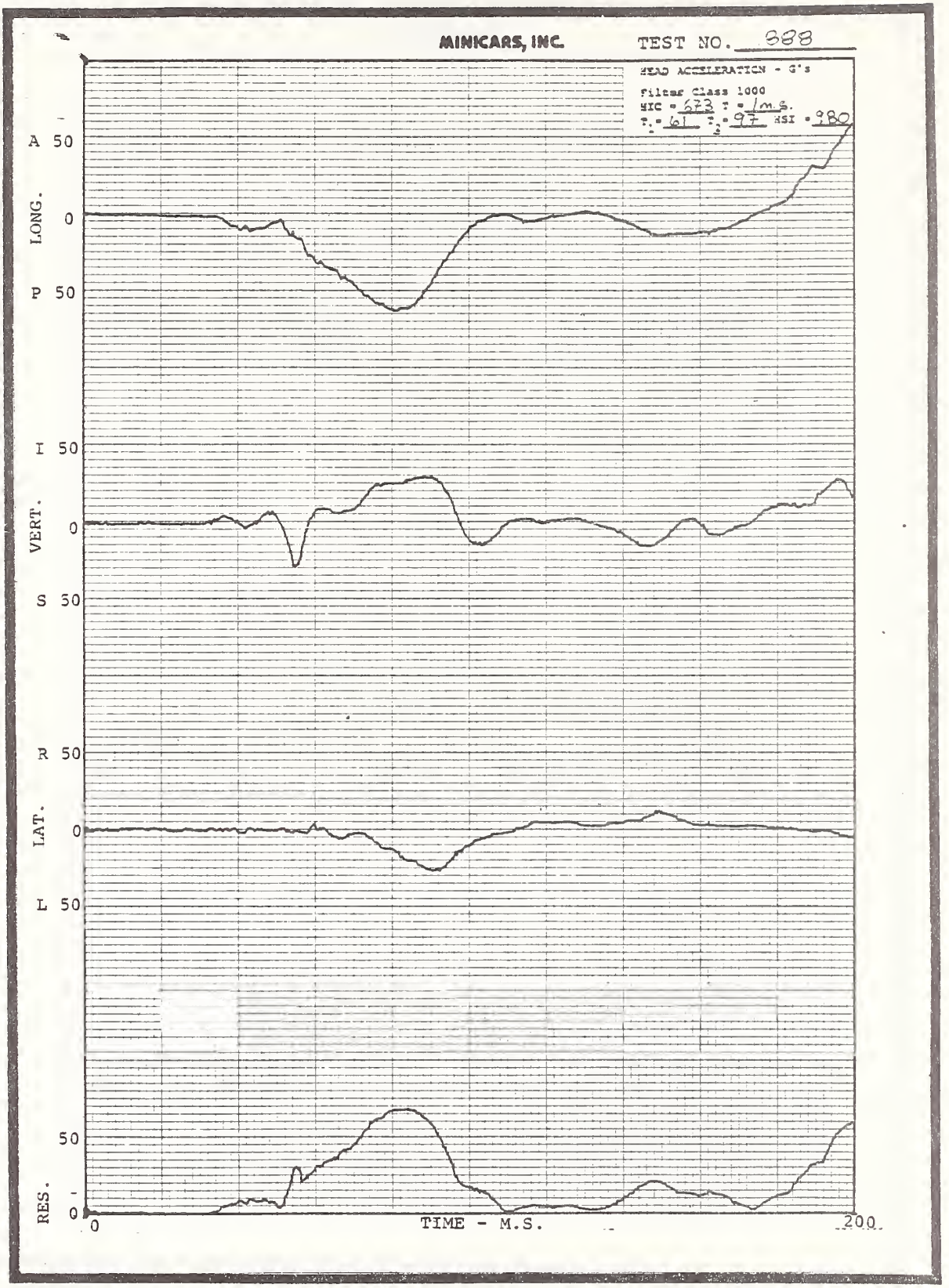

MINICARS, INC.
TEST NO. 1873
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 605
HSI = 747
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
TEST NO. 1372
Chest Acceleration - G's
Filter Class 180
CSI = 718
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

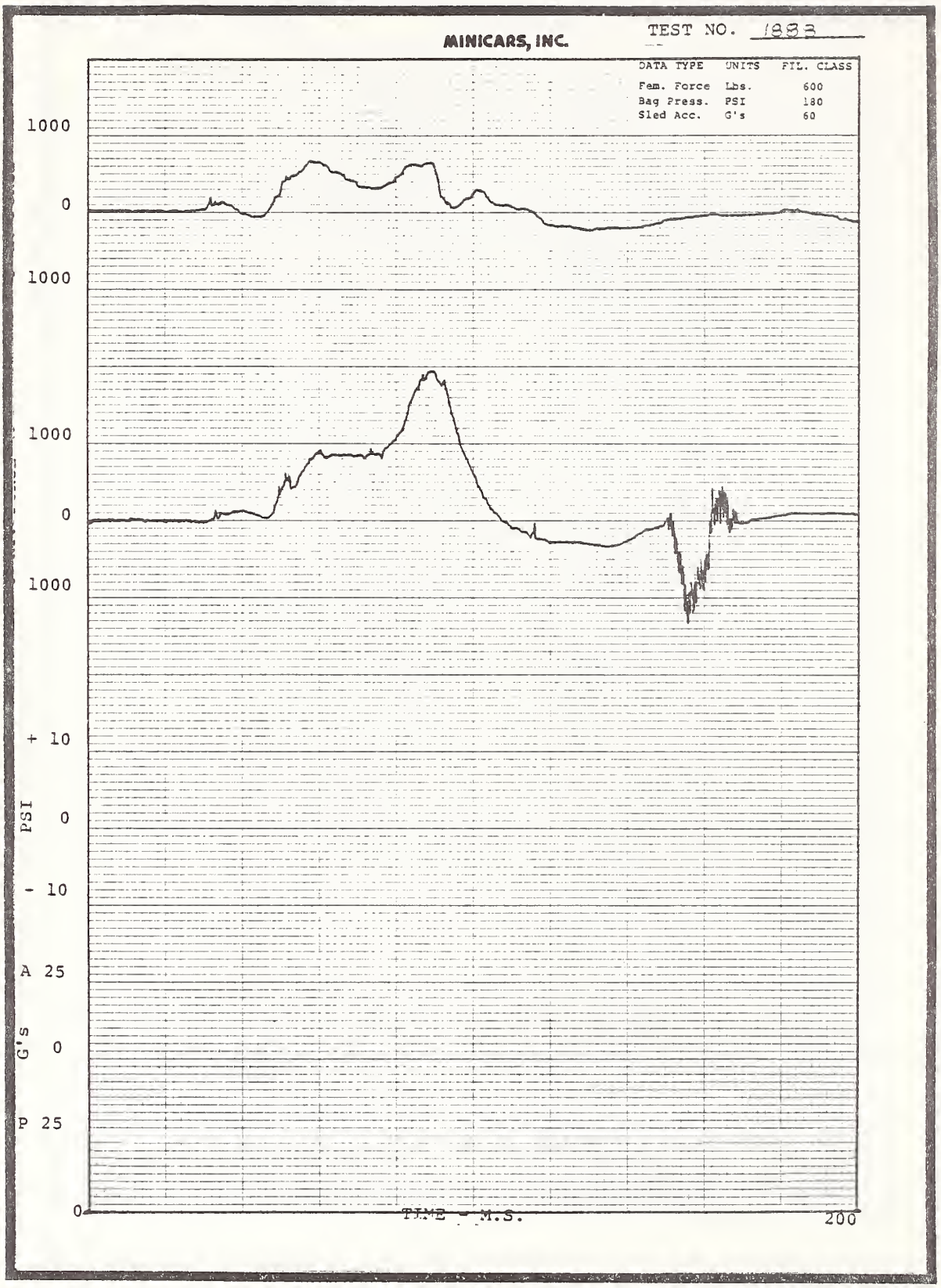

MINICARS, INC.
TEST NO.
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
1000
0
1000
1000
0
1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

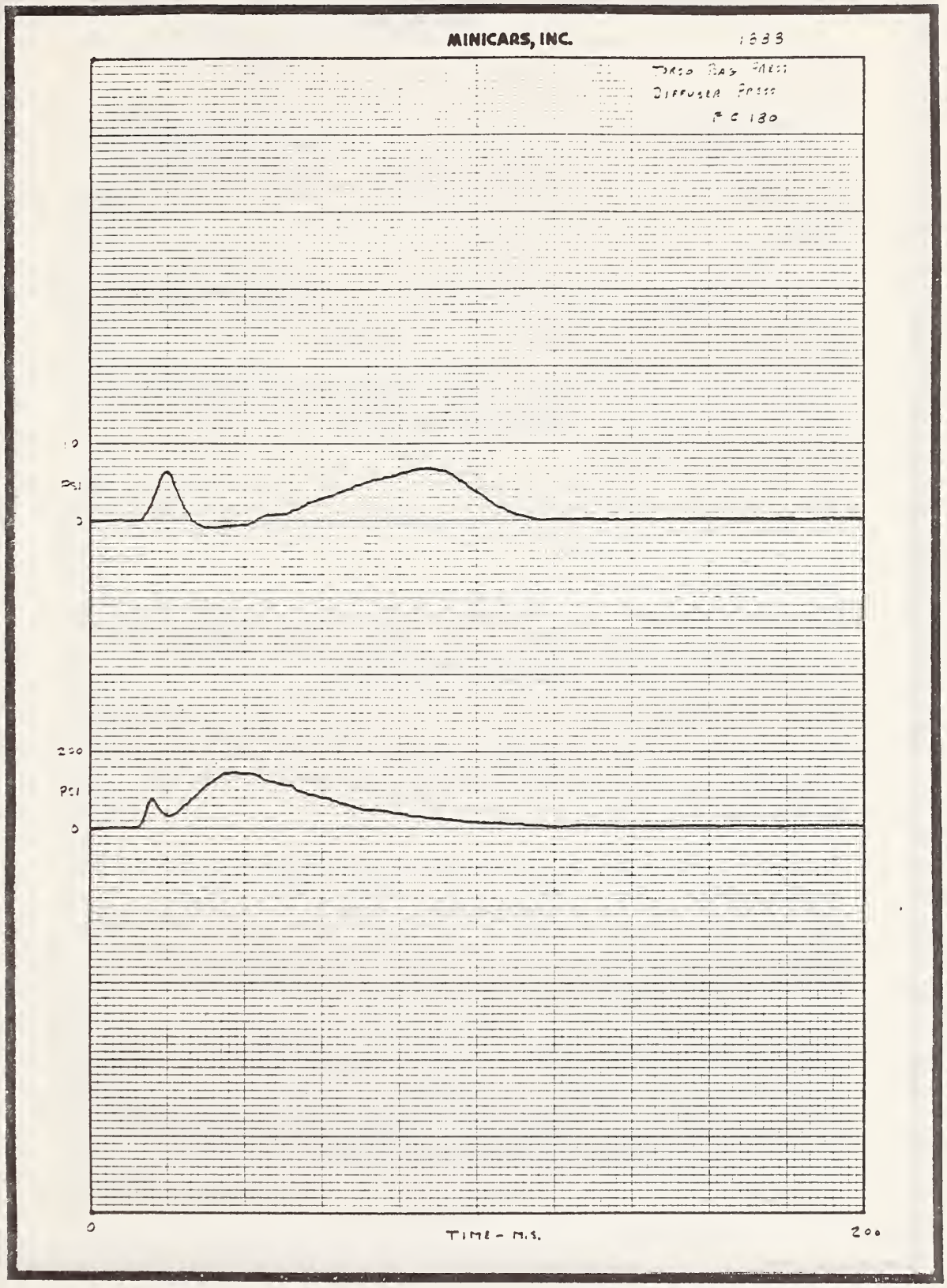

MINICARS, INC.
1872
TORSO BAG PRESS
DIFFUSER PRESS
10
PSI
0
200
PSI
0
0
TIME - M.S.
200

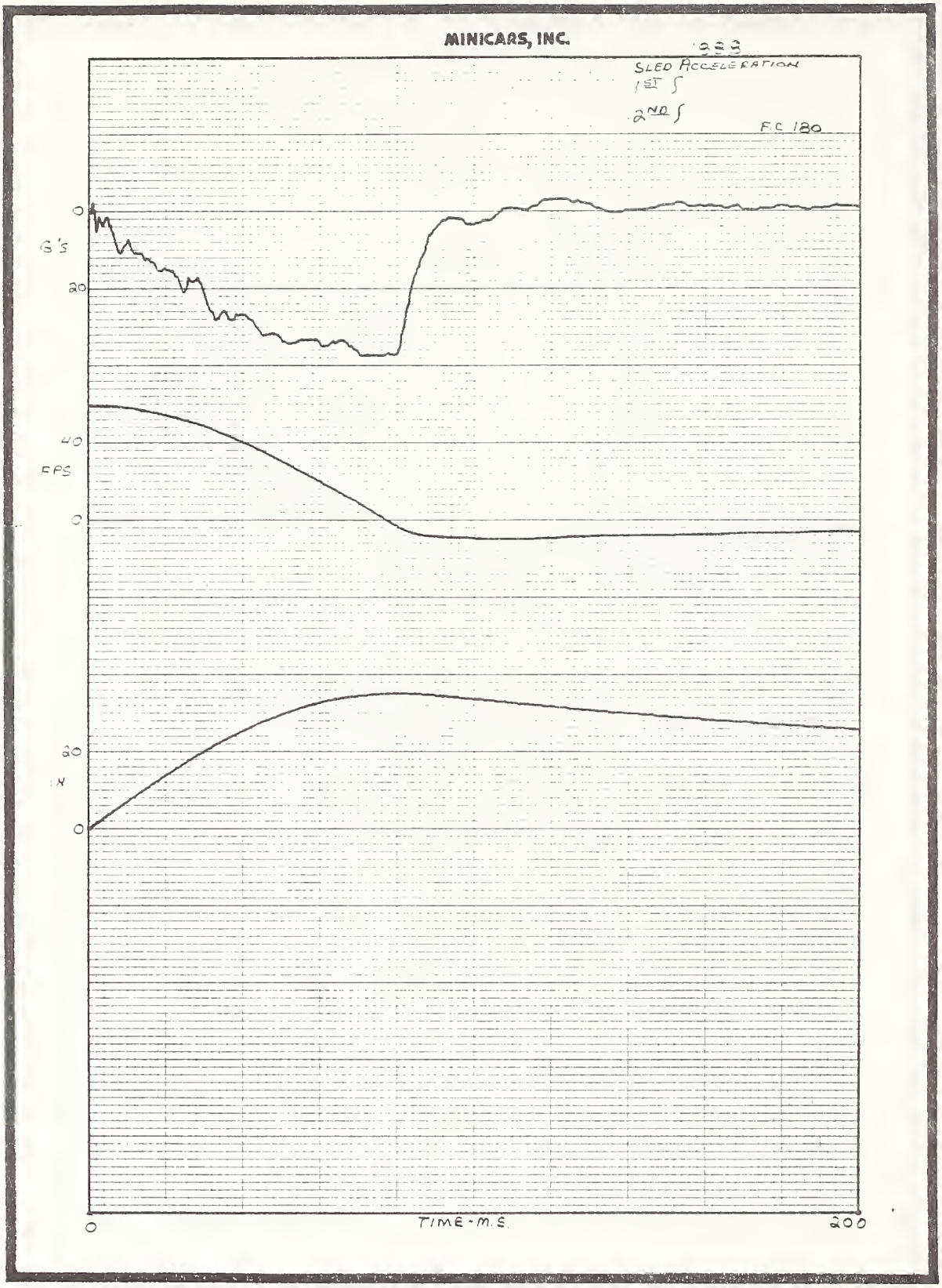

MINICARS, INC.
.372
SLED ACC
1ST ∫
2ND ∫
F C 180
0
G's
20
40
FPS
0
20
IN
0
0
TIME - M.S.
200

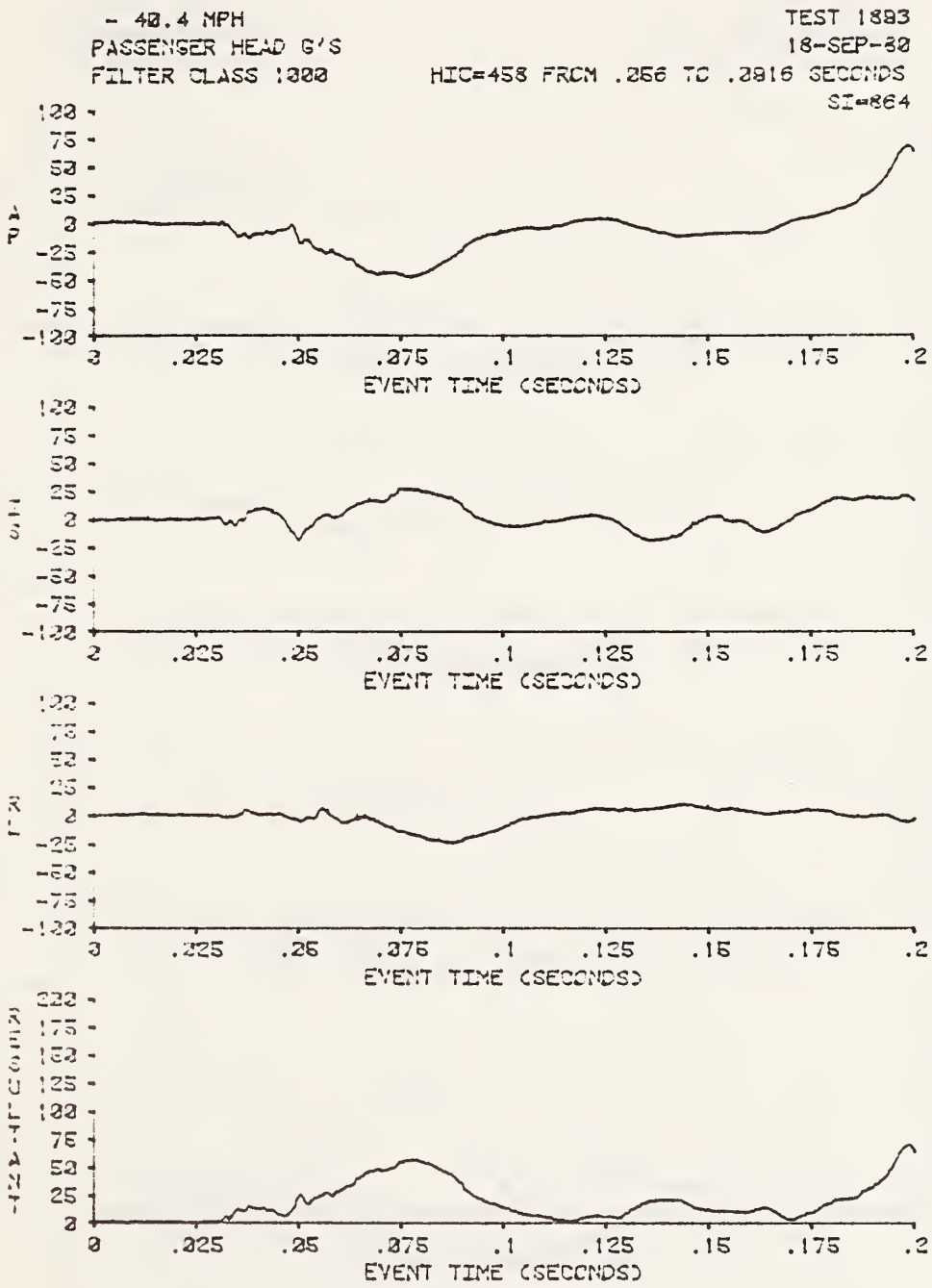

MINICARS, INC.
TEST NO. 388
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 673 T = 1m.s.
T = 61 T = 97 HSI = 980
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

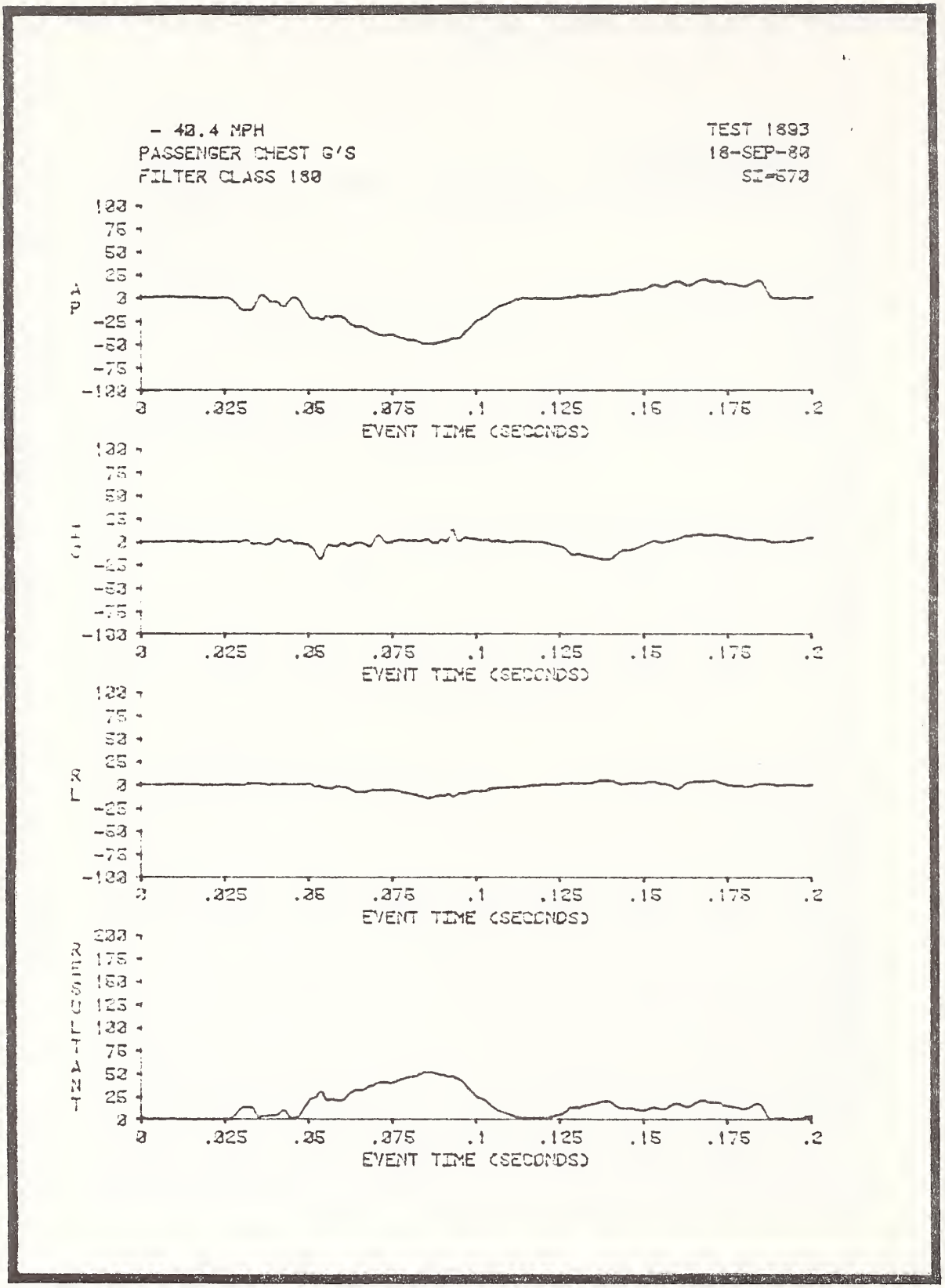
MINICARS, INC.
TEST NO. 1888
Chest Acceleration - G's
Filter Class 180
CSI = 724
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

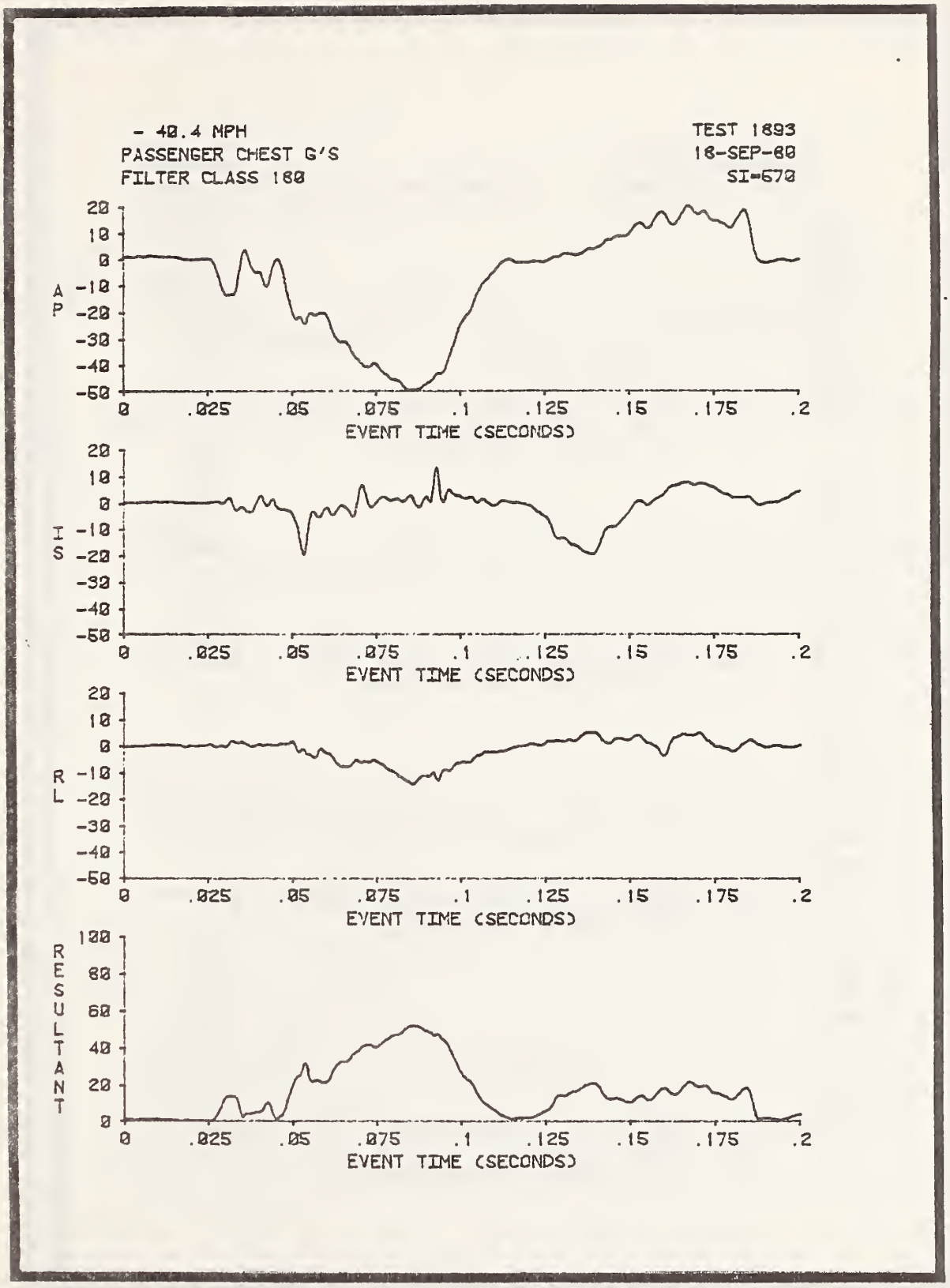

MINICARS, INC.
TEST NO. 1883
DATA TYPE UNITS FIL. CLASS
Fem. Force Lbs. 600
Bag Press. PSI 180
Sled Acc. G's 60
1000
0
1000
1000
0
1000
+ 10
PSI 0
- 10
A 25
G's 0
P 25
0
TIME - M.S.
200

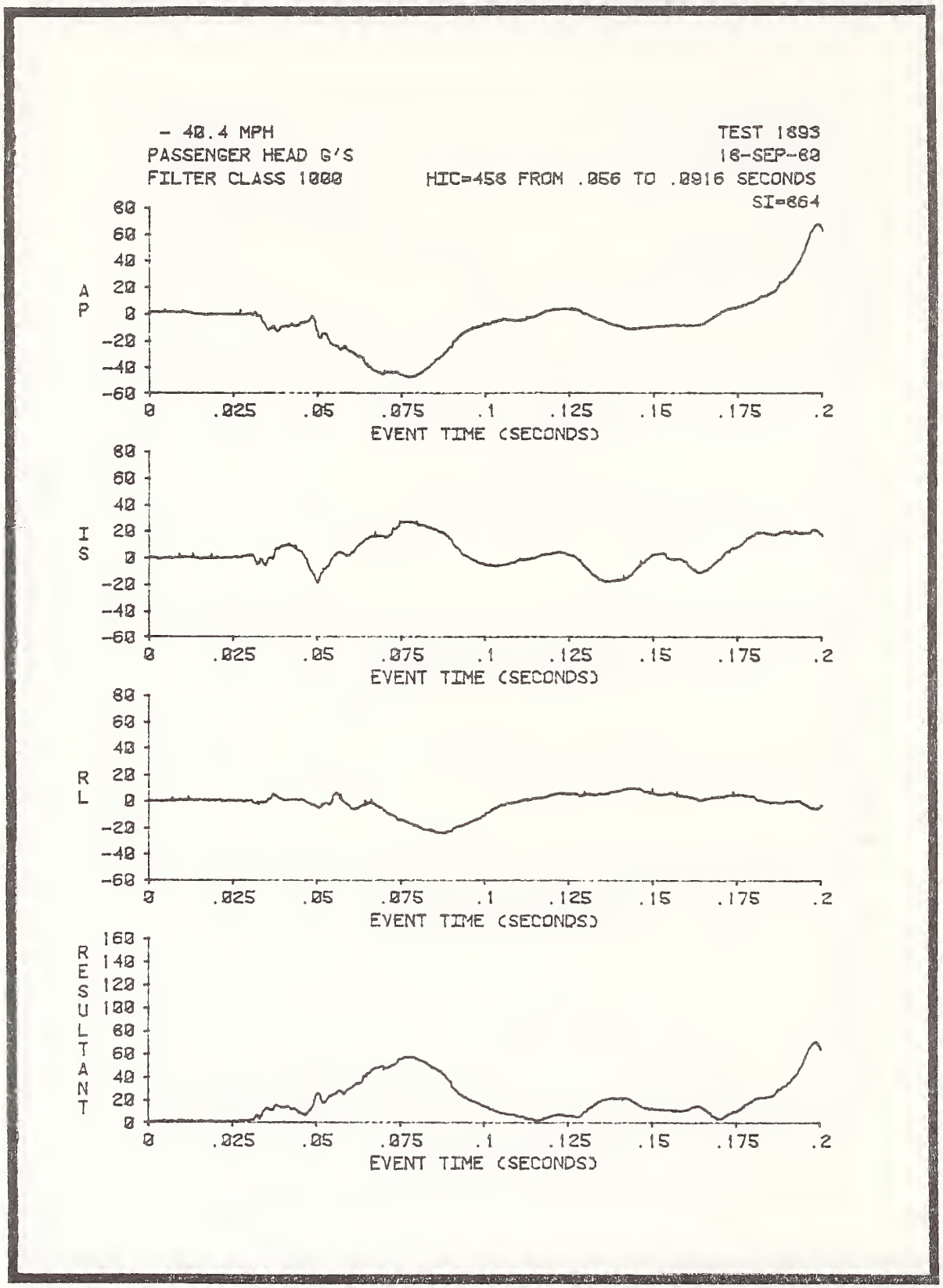

MINICARS, INC.
1883
DIFFUSER POSITION
10
PSI
0
200
PSI
0
0
TIME - M.S.
200


MINICARS, INC.
SLED ACCELERATION
1ST ∫
2ND ∫
FC 180
0
G'S
20
40
FPS
0
20
IN
0
0
TIME - M.S.
200

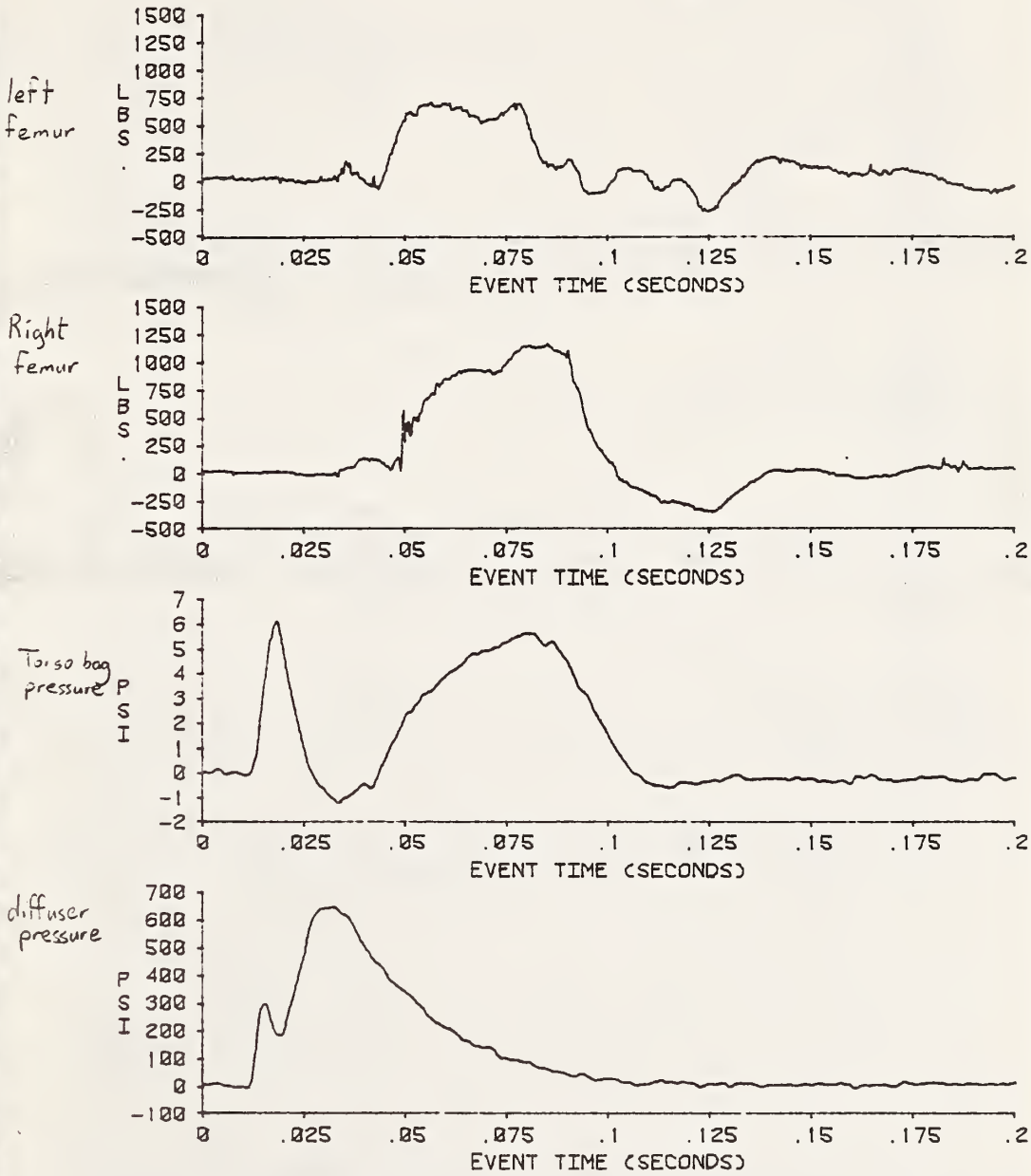

- 40.4 MPH
PASSENGER HEAD G'S
FILTER CLASS 1000
TEST 1893
18-SEP-80
HIC=458 FROM .266 TO .2816 SECONDS
SI=864
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)

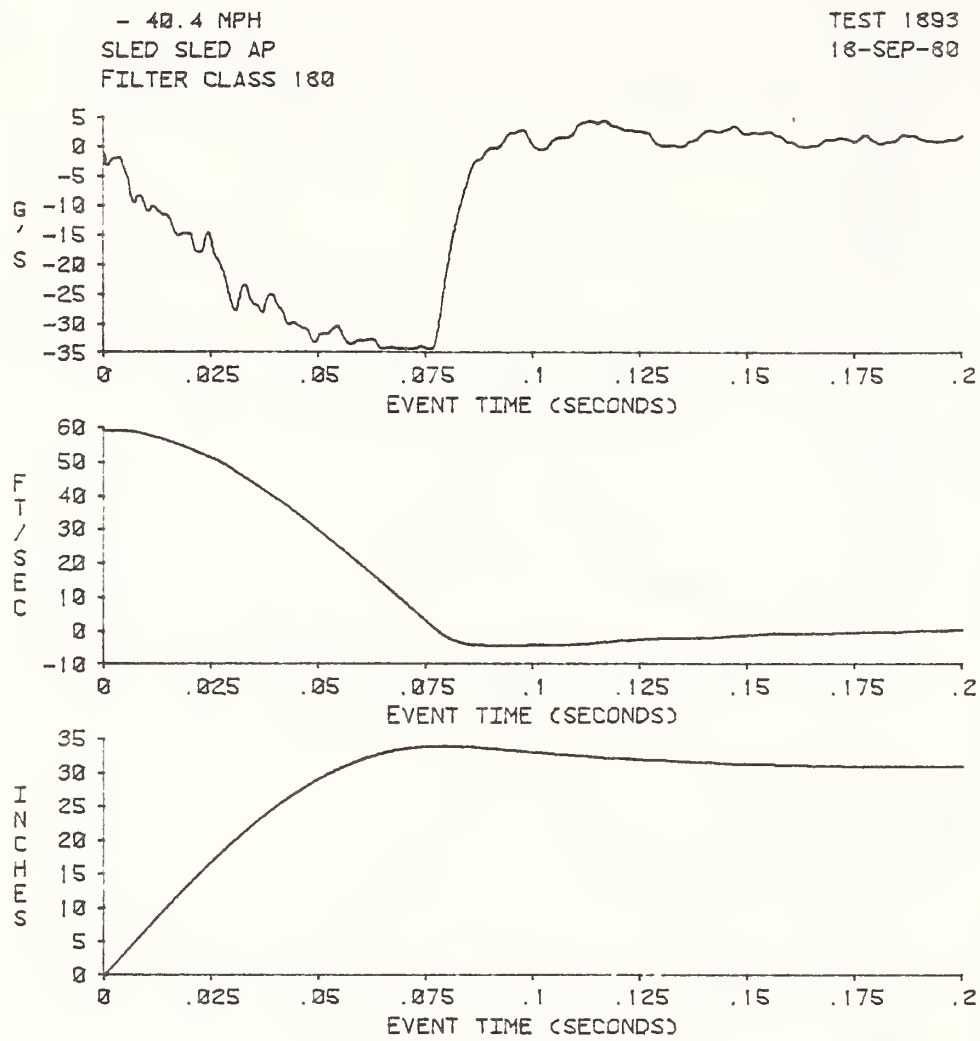

- 40.4 MPH
PASSENGER CHEST G'S
FILTER CLASS 180
TEST 1893
18-SEP-80
SI=670
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)


- 40.4 MPH
PASSENGER CHEST G'S
FILTER CLASS 180
TEST 1893
18-SEP-80
SI=670
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

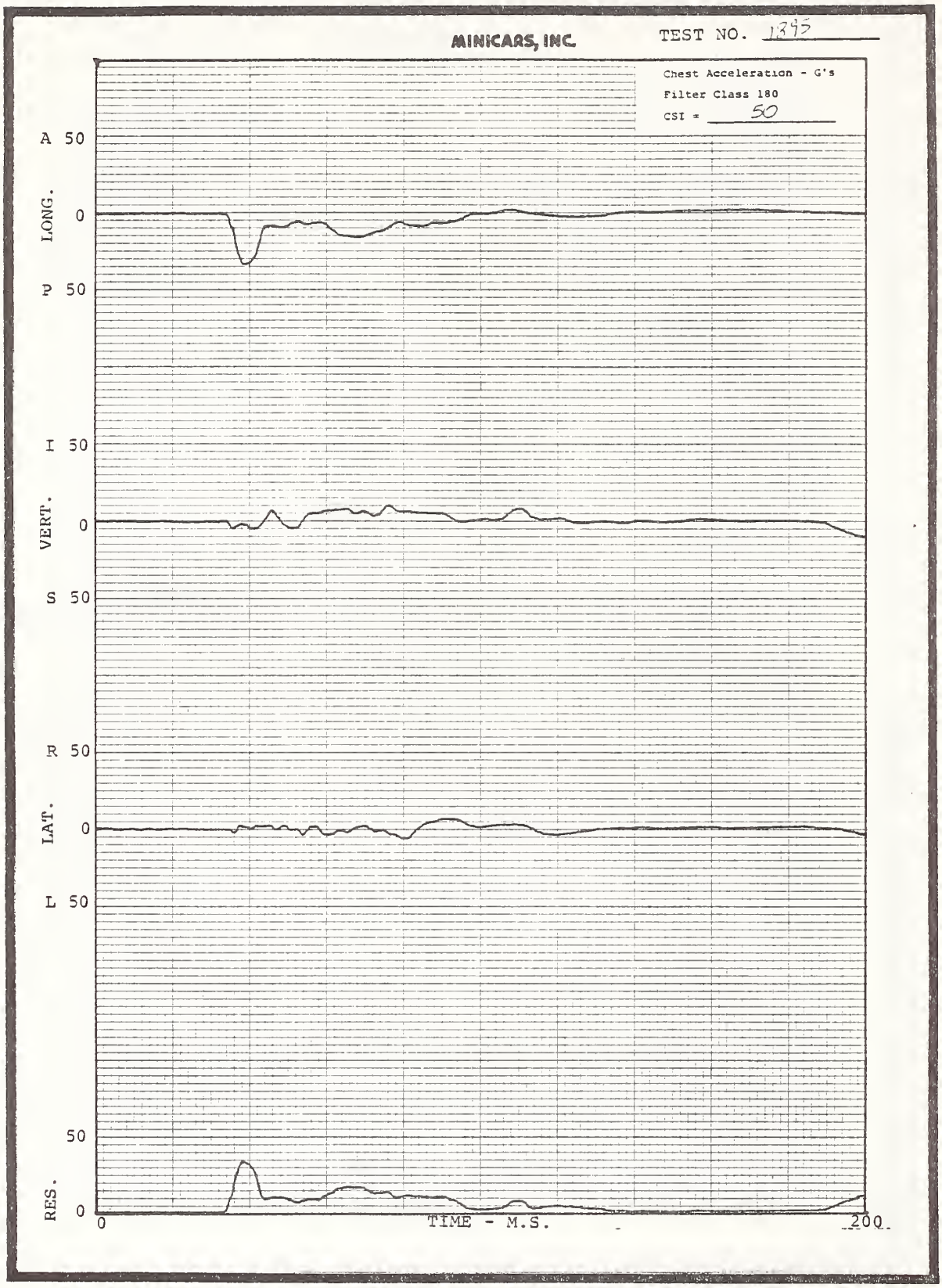

- 40.4 MPH
PASSENGER HEAD G'S
FILTER CLASS 1000
TEST 1893
16-SEP-68
HIC=458 FROM .056 TO .0916 SECONDS
SI=864
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

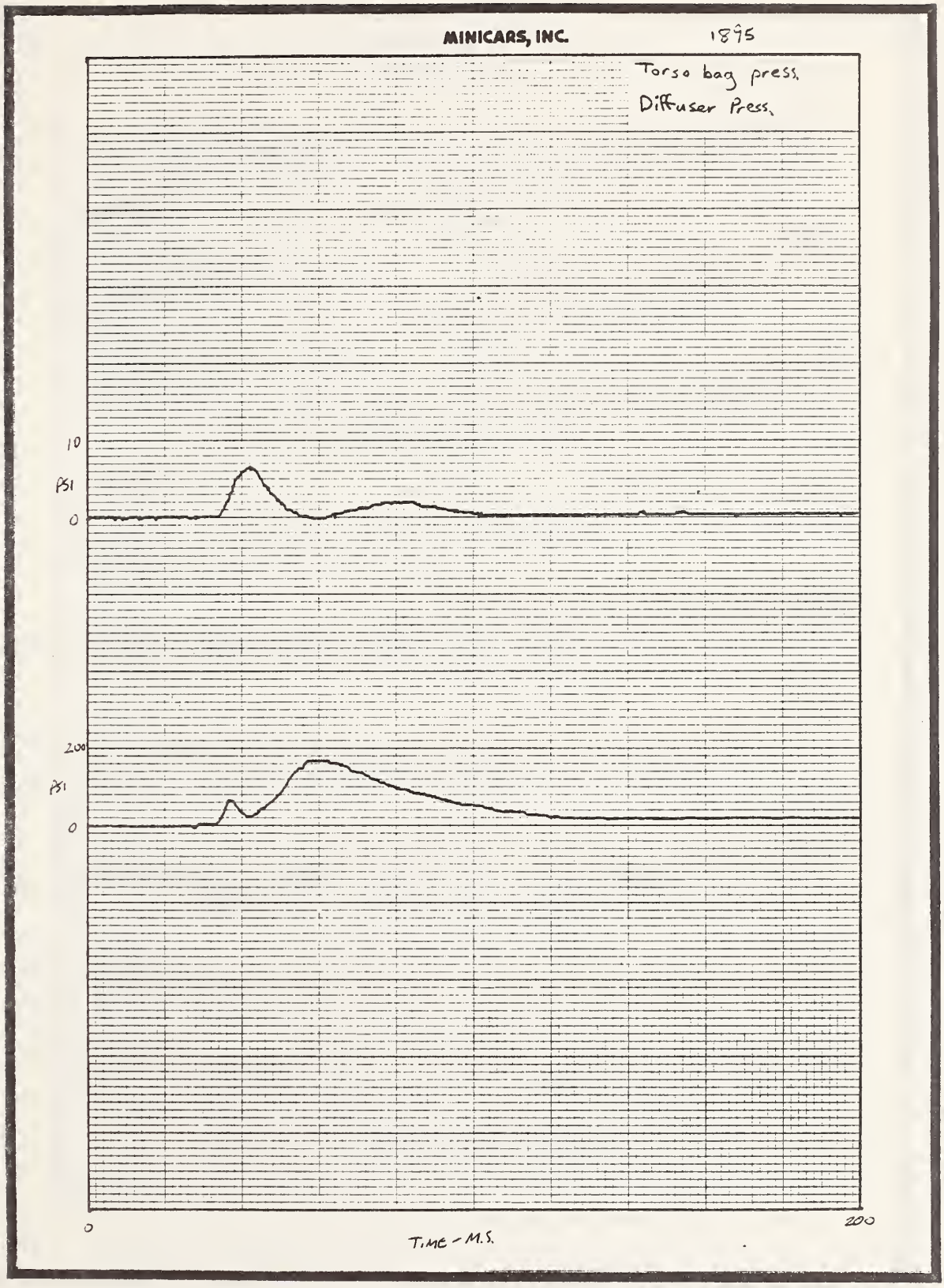
1893

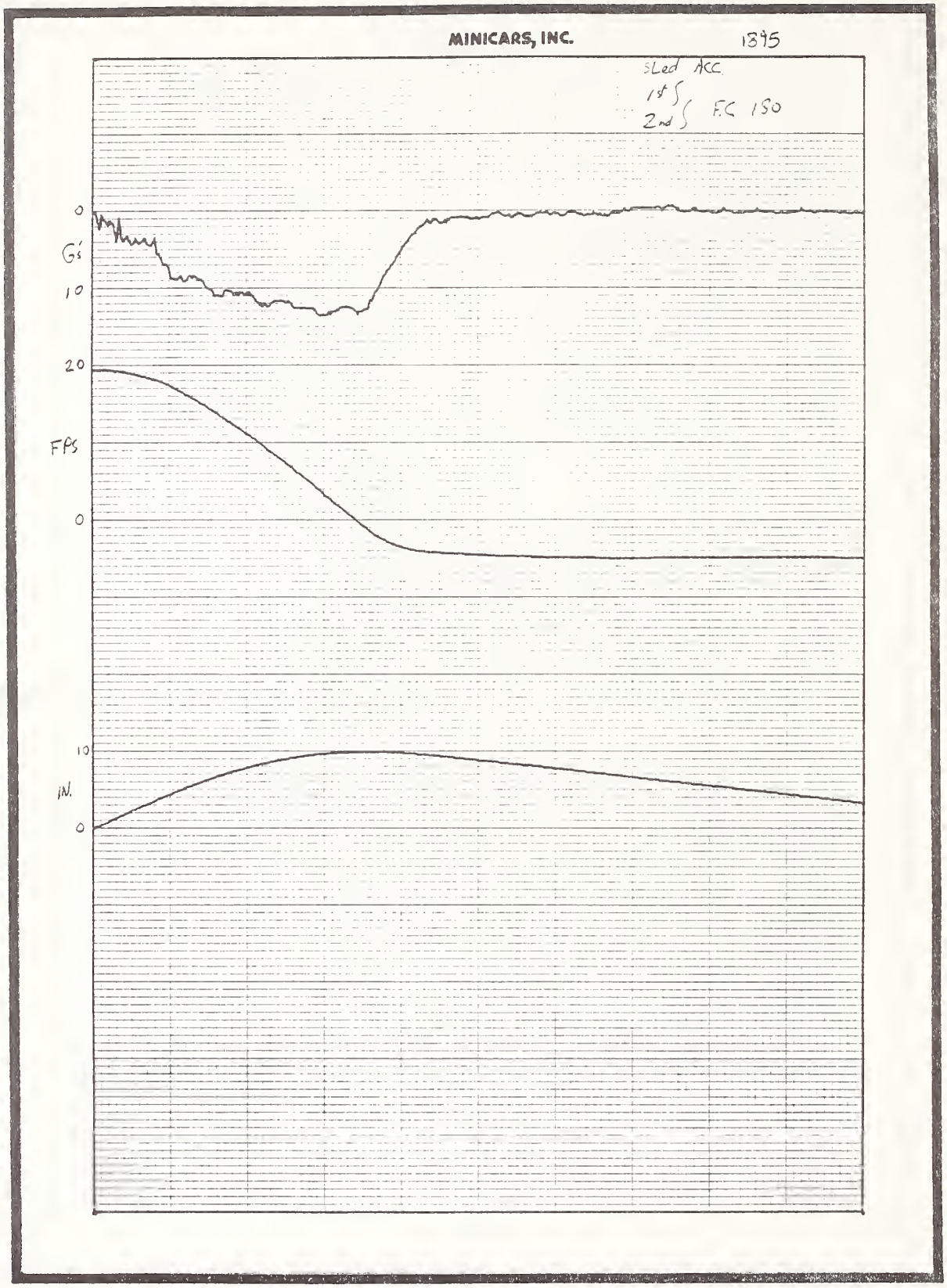

left femur
LBS.
1500
1250
1000
750
500
250
0
-250
-500
0 .025 .05 .075 .1 .125 .15 .175 .2
EVENT TIME (SECONDS)
Right femur
LBS.
1500
1250
1000
750
500
250
0
-250
-500
0 .025 .05 .075 .1 .125 .15 .175 .2
EVENT TIME (SECONDS)
Torso bag pressure
PSI
7
6
5
4
3
2
1
0
-1
-2
0 .025 .05 .075 .1 .125 .15 .175 .2
EVENT TIME (SECONDS)
diffuser pressure
PSI
700
600
500
400
300
200
100
0
-100
0 .025 .05 .075 .1 .125 .15 .175 .2
EVENT TIME (SECONDS)

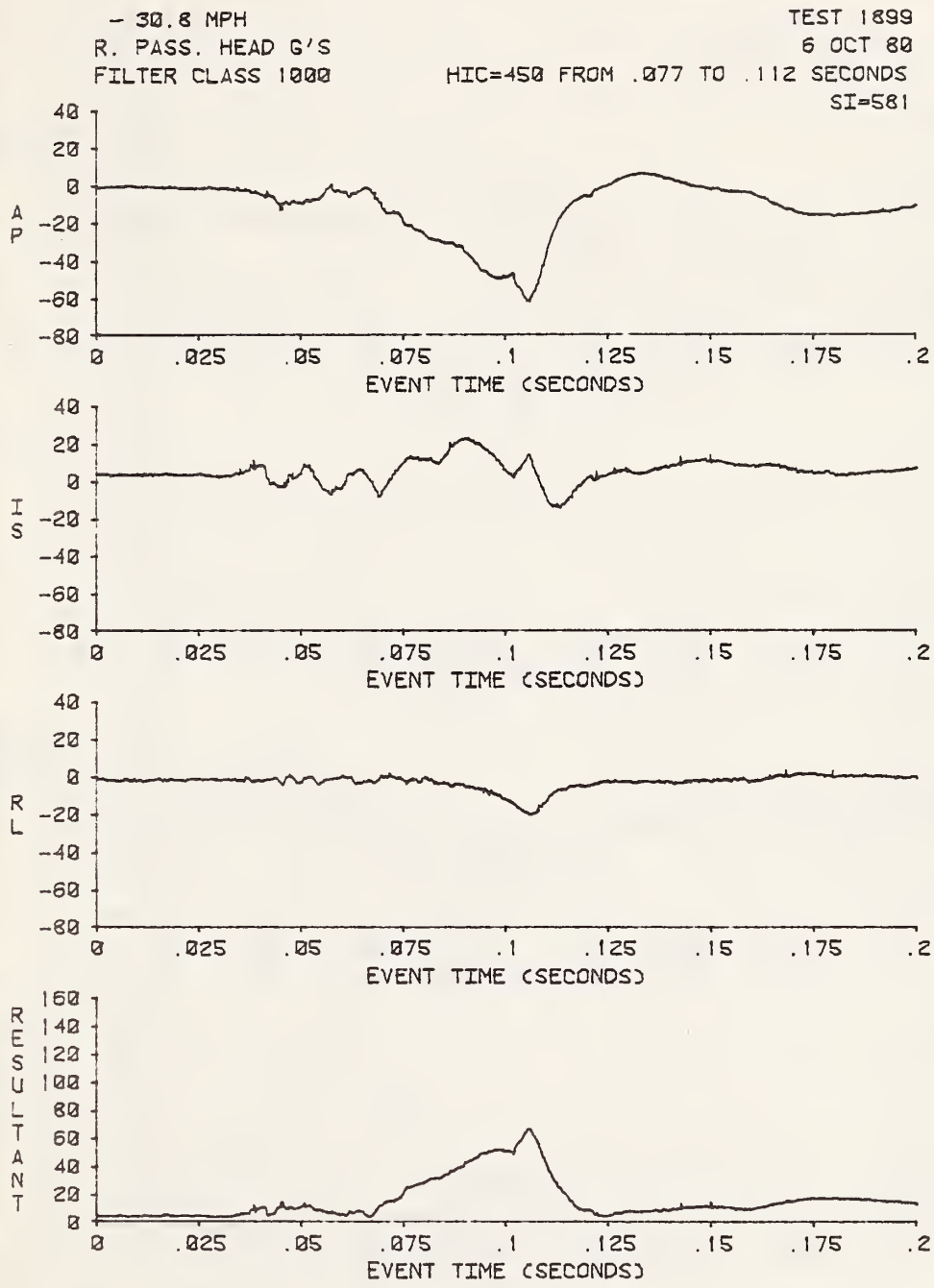

- 40.4 MPH
SLED SLED AP
FILTER CLASS 180
TEST 1893
18-SEP-80
G'S
5
0
-5
-10
-15
-20
-25
-30
-35
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)

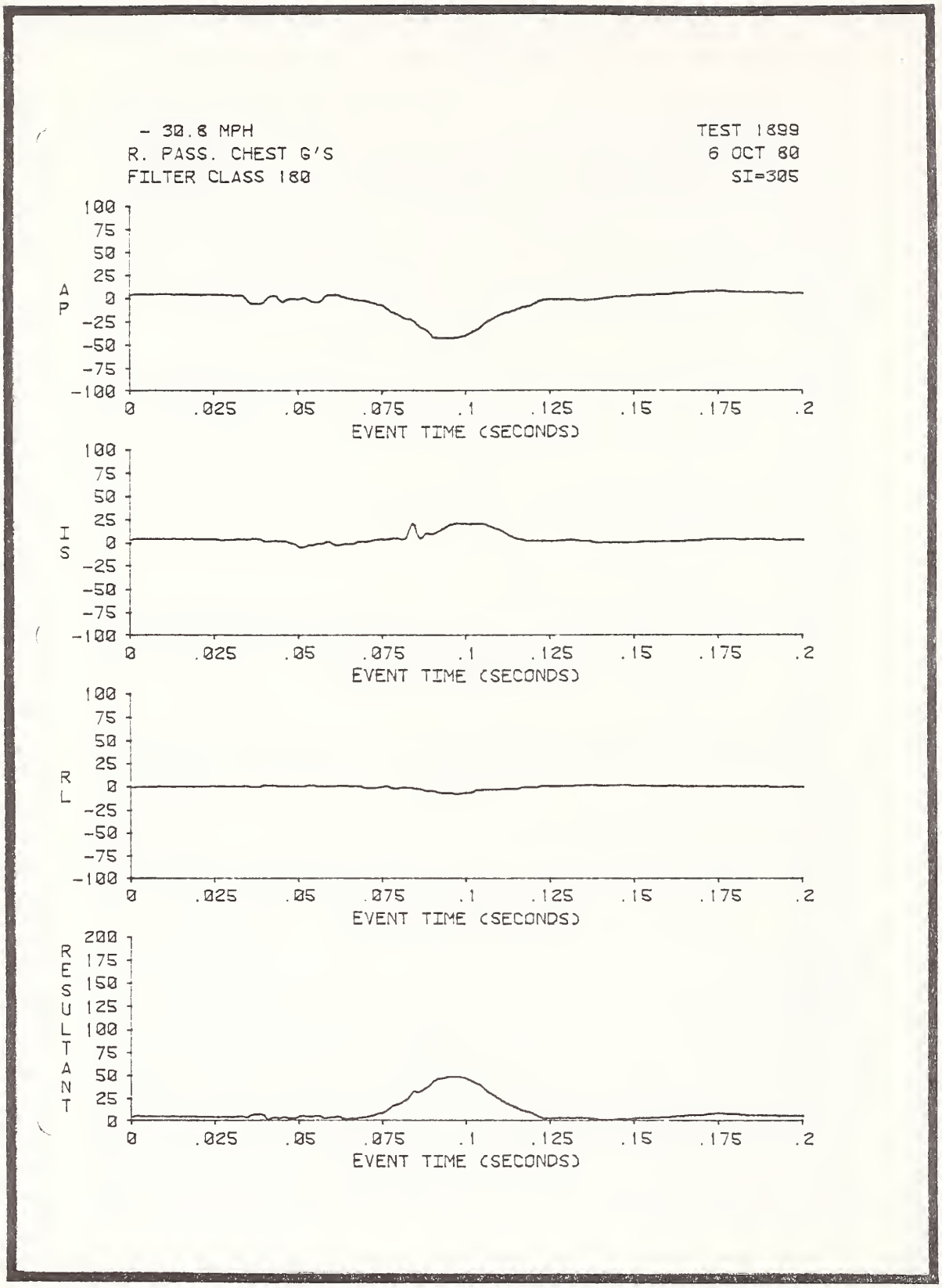
MINICARS, INC.
TEST NO. 1395
HEAD ACCELERATION - G's
Filter Class 1000
HIC = 90
HSI = 124
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
TEST NO. 1395
Chest Acceleration - G's
Filter Class 180
CSI = 50
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200


MINICARS, INC.
1895
Torso bag press.
Diffuser Press.
10
PSI
0
200
PSI
0
0
200
TIME - M.S.

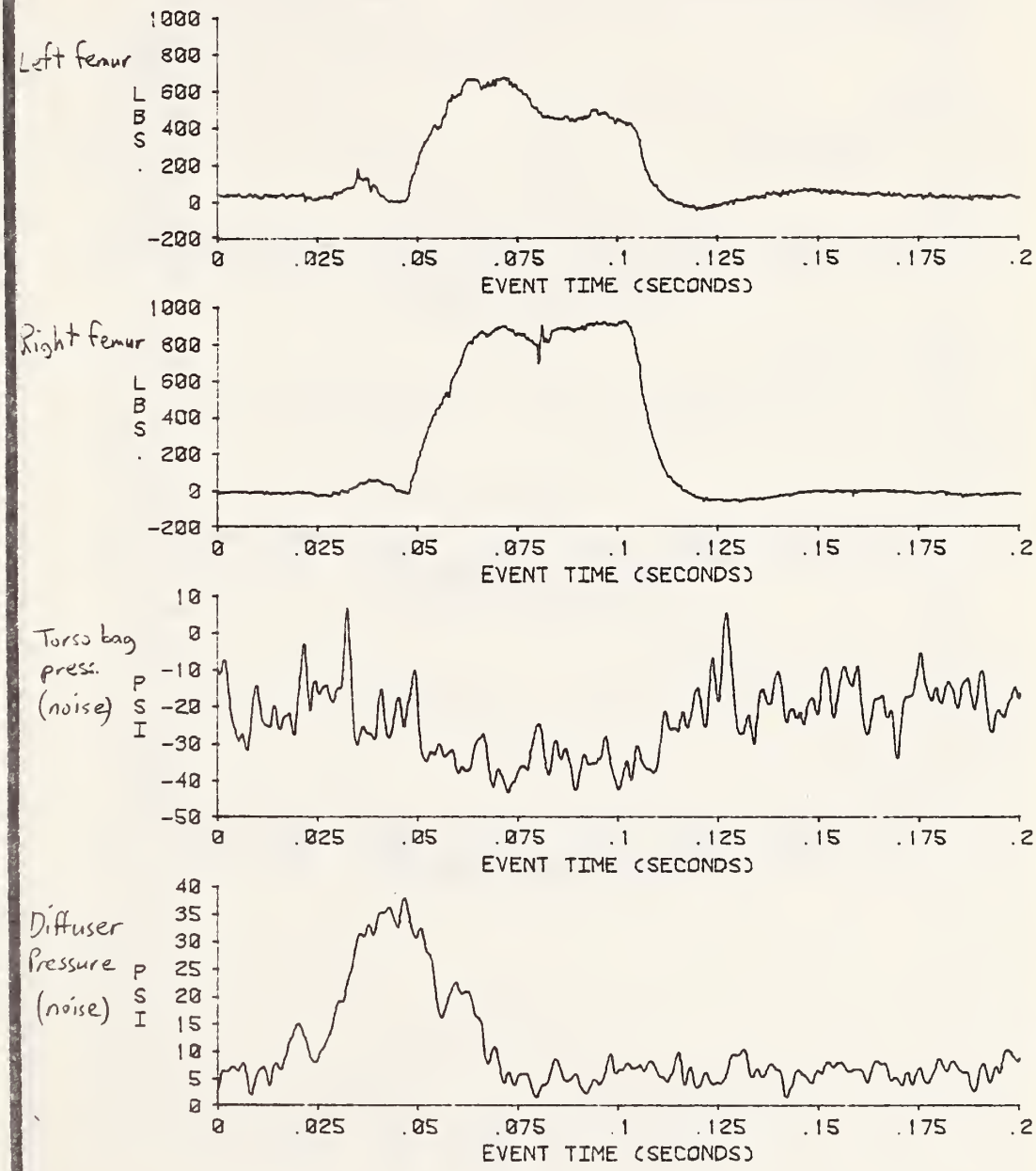

MINICARS, INC.
1395
Sled Acc.
1st ∫
2nd ∫ F.C 150
0
G's
10
20
FPS
0
10
IN.
0

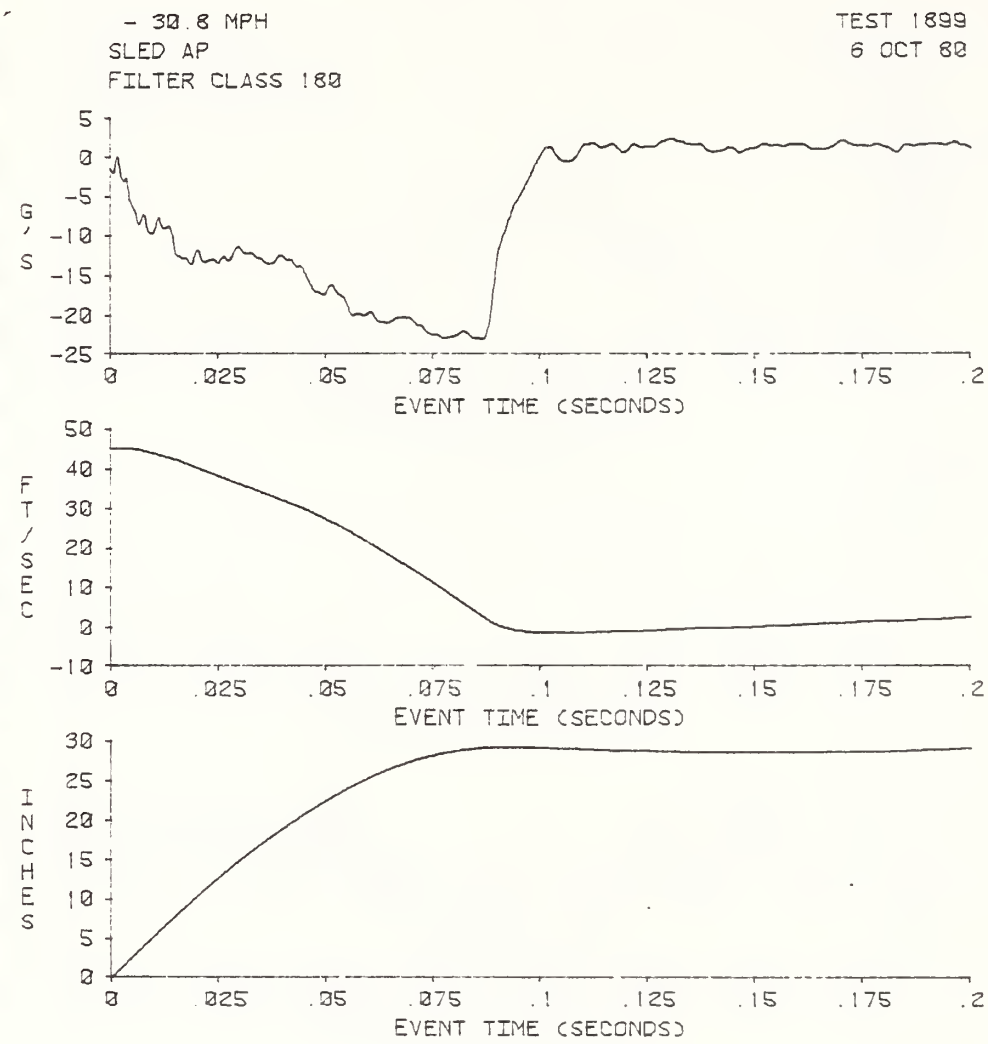

- 30.8 MPH
R. PASS. HEAD G'S
FILTER CLASS 1000
TEST 1899
6 OCT 80
HIC=450 FROM .077 TO .112 SECONDS
SI=581
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

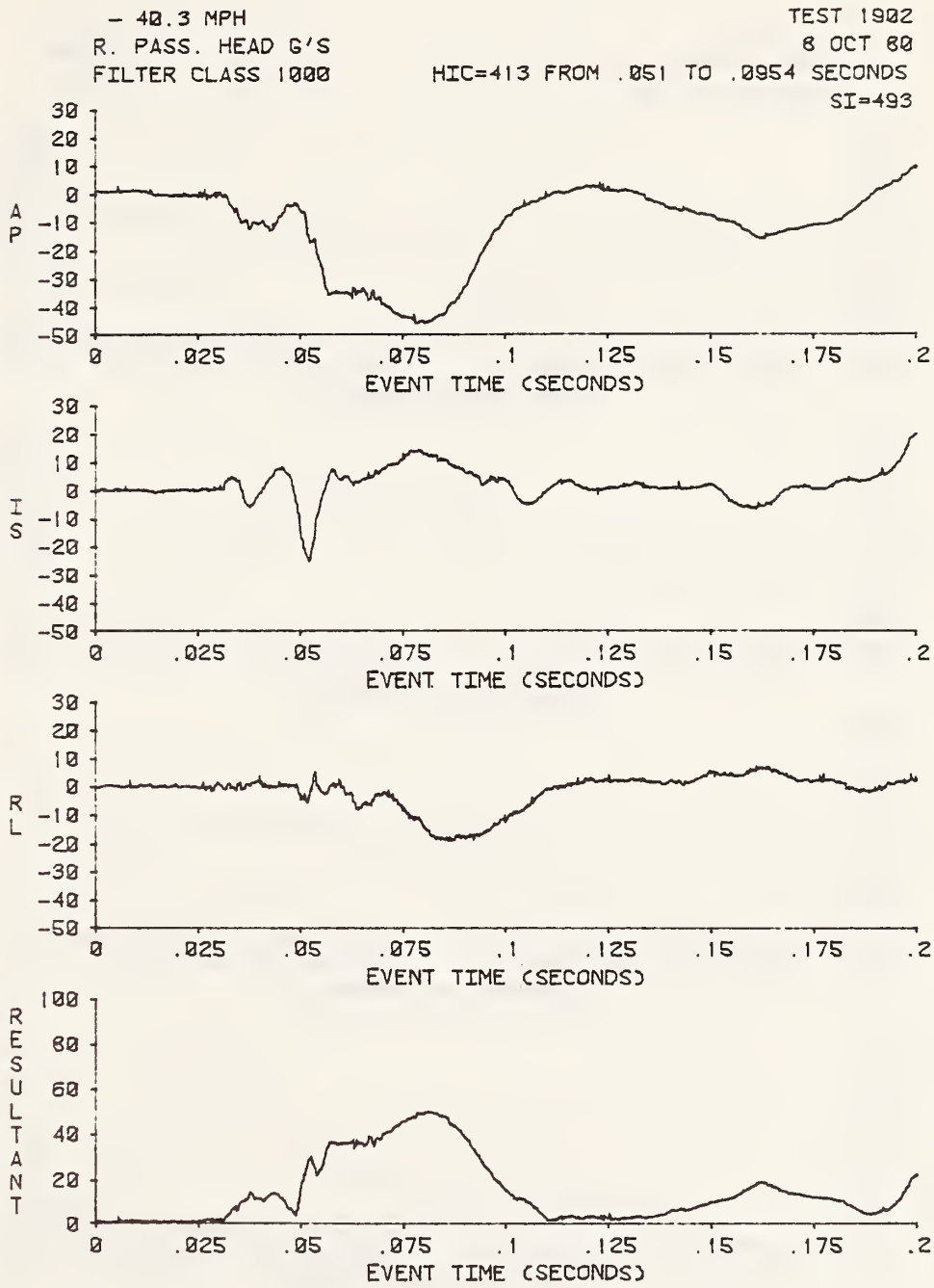

- 30.8 MPH
R. PASS. CHEST G'S
FILTER CLASS 180
TEST 1899
6 OCT 80
SI=305
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

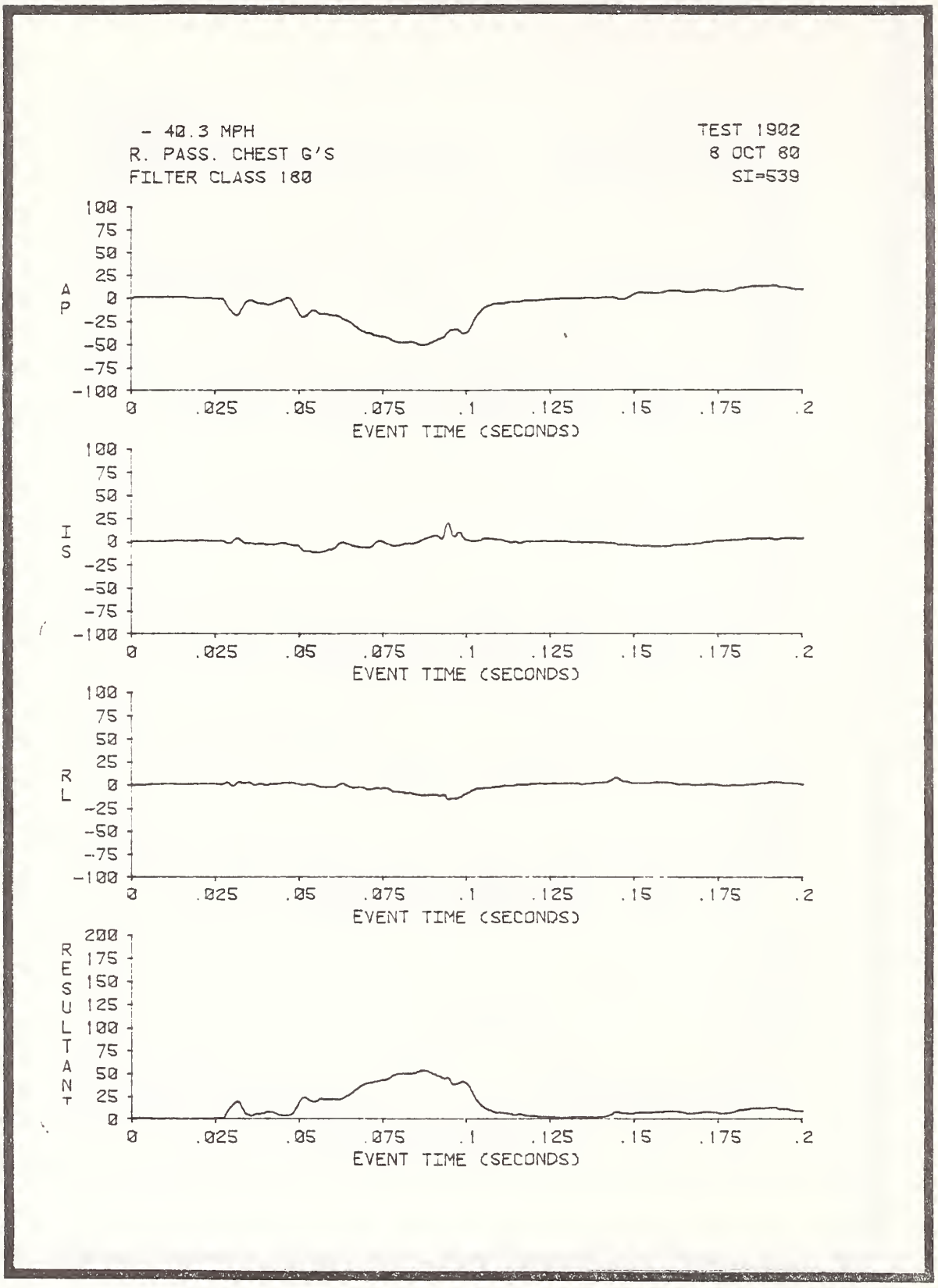
30.8 MPH

TEST 1899
6 OCT 80



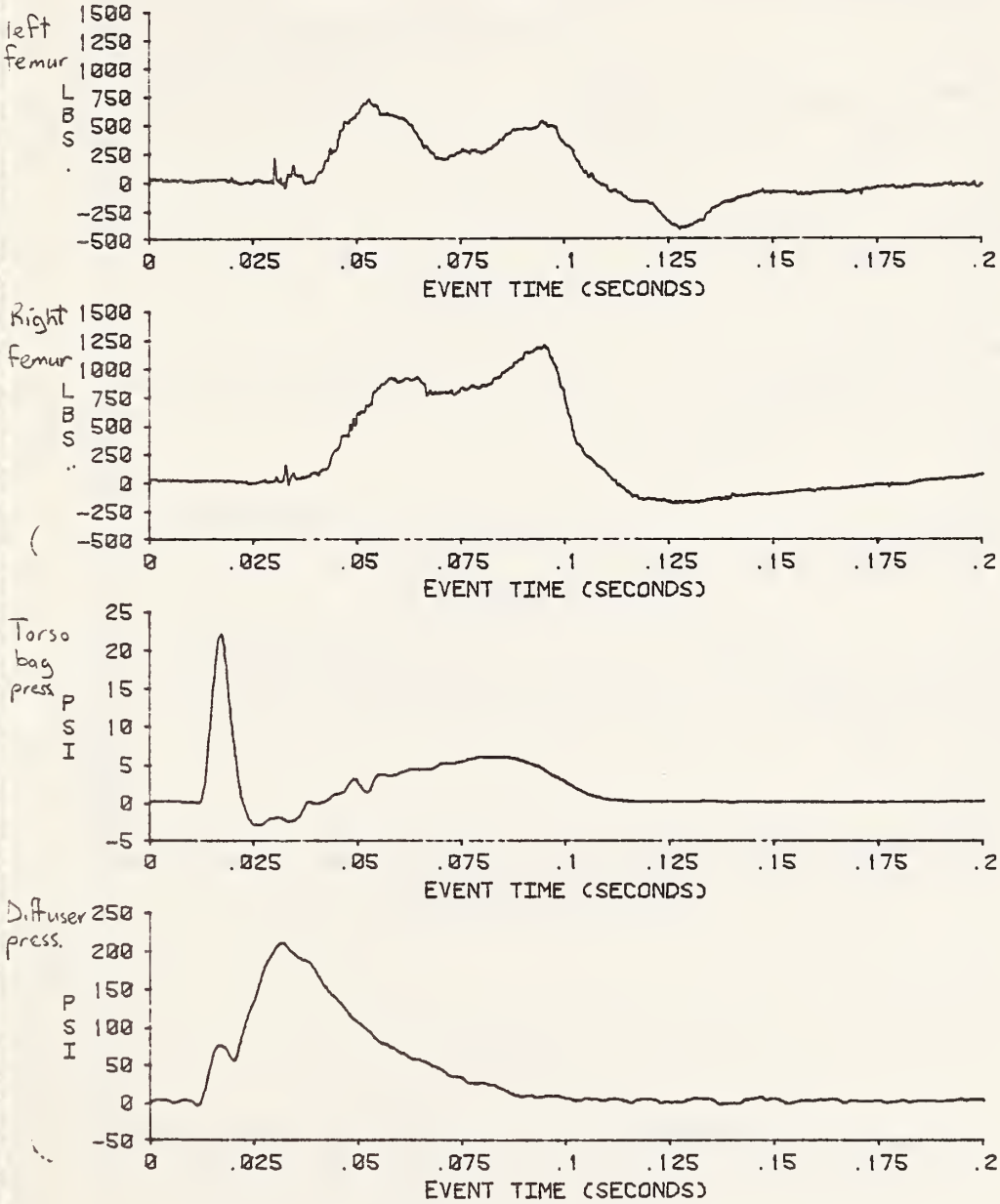

- 30.8 MPH
SLED AP
FILTER CLASS 180
TEST 1899
6 OCT 80
G'S
5
0
-5
-10
-15
-20
-25
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
30
25
20
15
10
5
0
EVENT TIME (SECONDS)

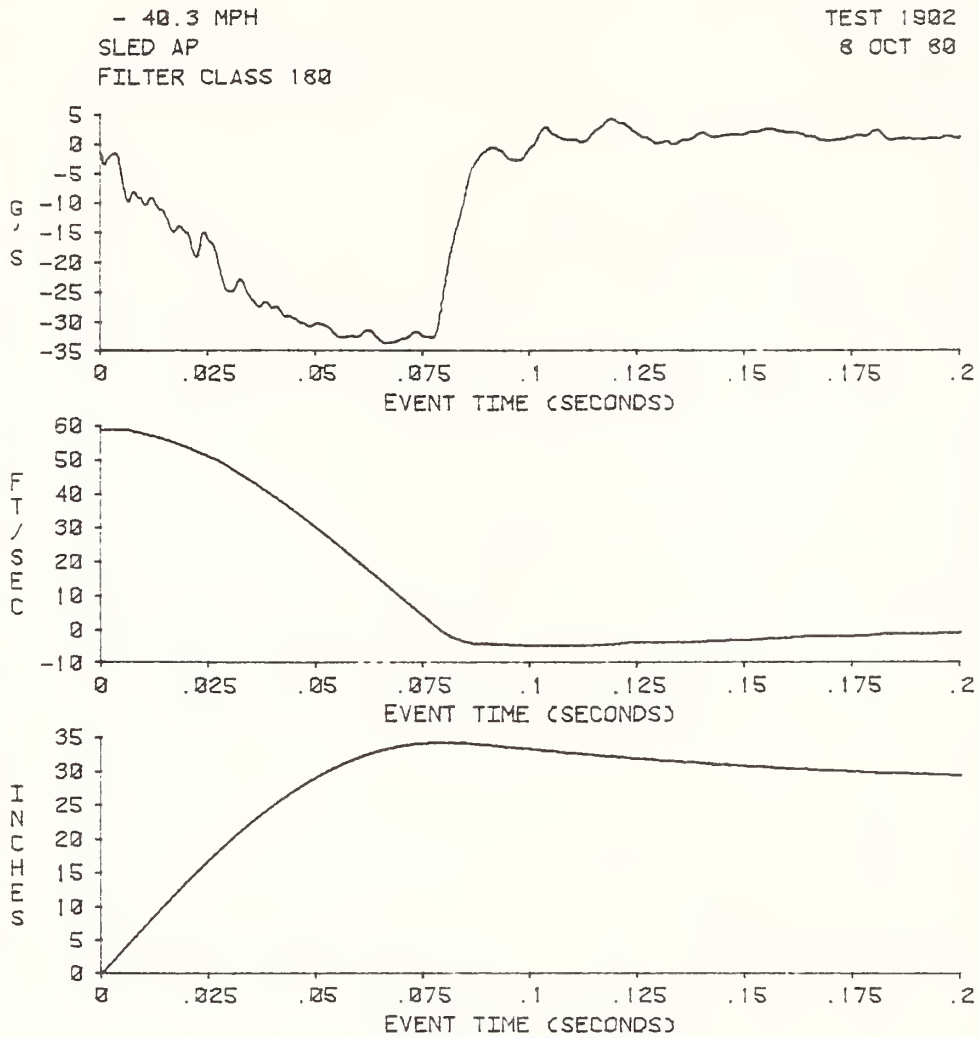

- 40.3 MPH
R. PASS. HEAD G'S
FILTER CLASS 1000
TEST 1902
6 OCT 80
HIC=413 FROM .051 TO .0954 SECONDS
SI=493
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

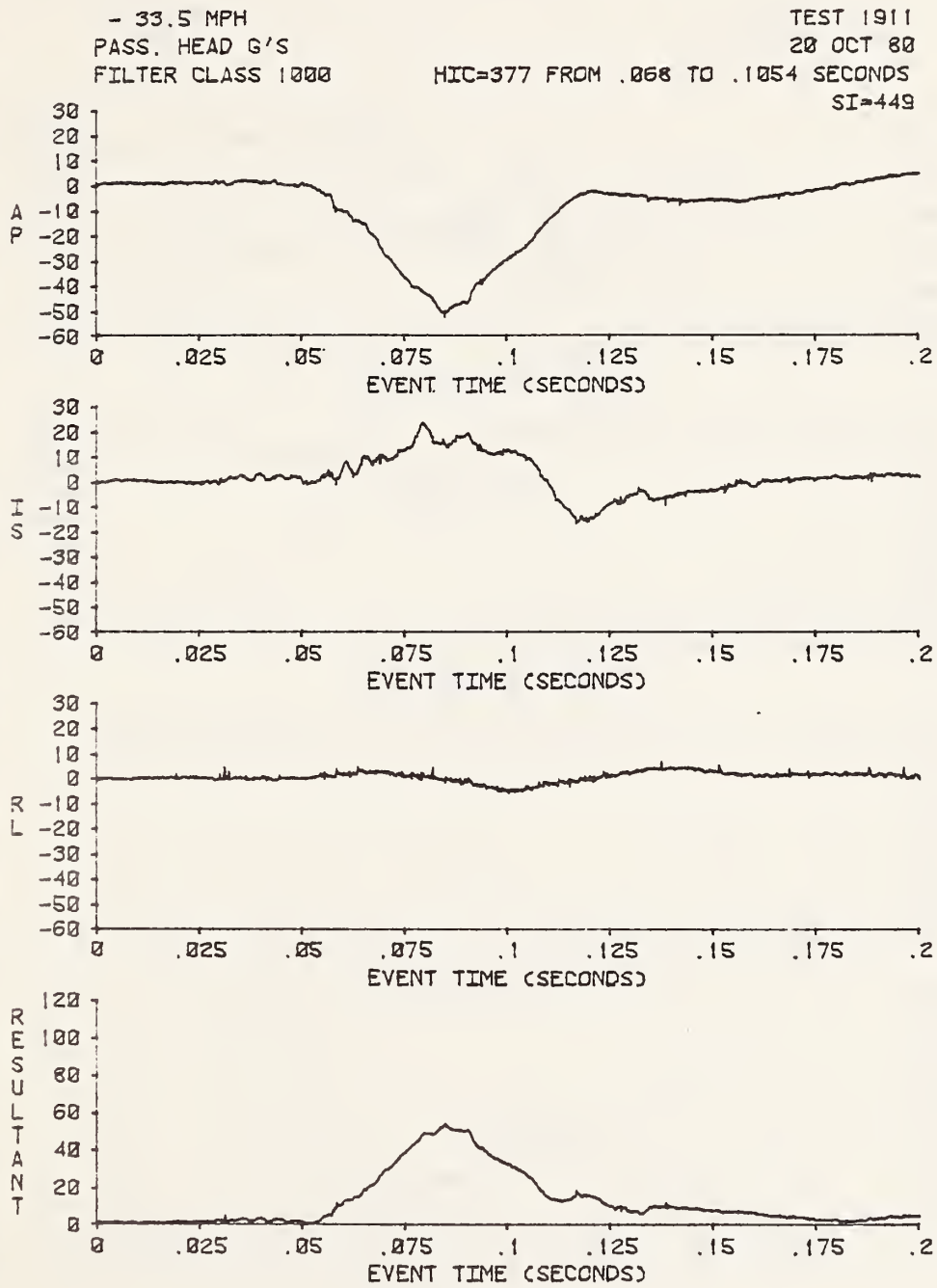

- 40.3 MPH
R. PASS. CHEST G'S
FILTER CLASS 180
TEST 1902
8 OCT 80
SI=539
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

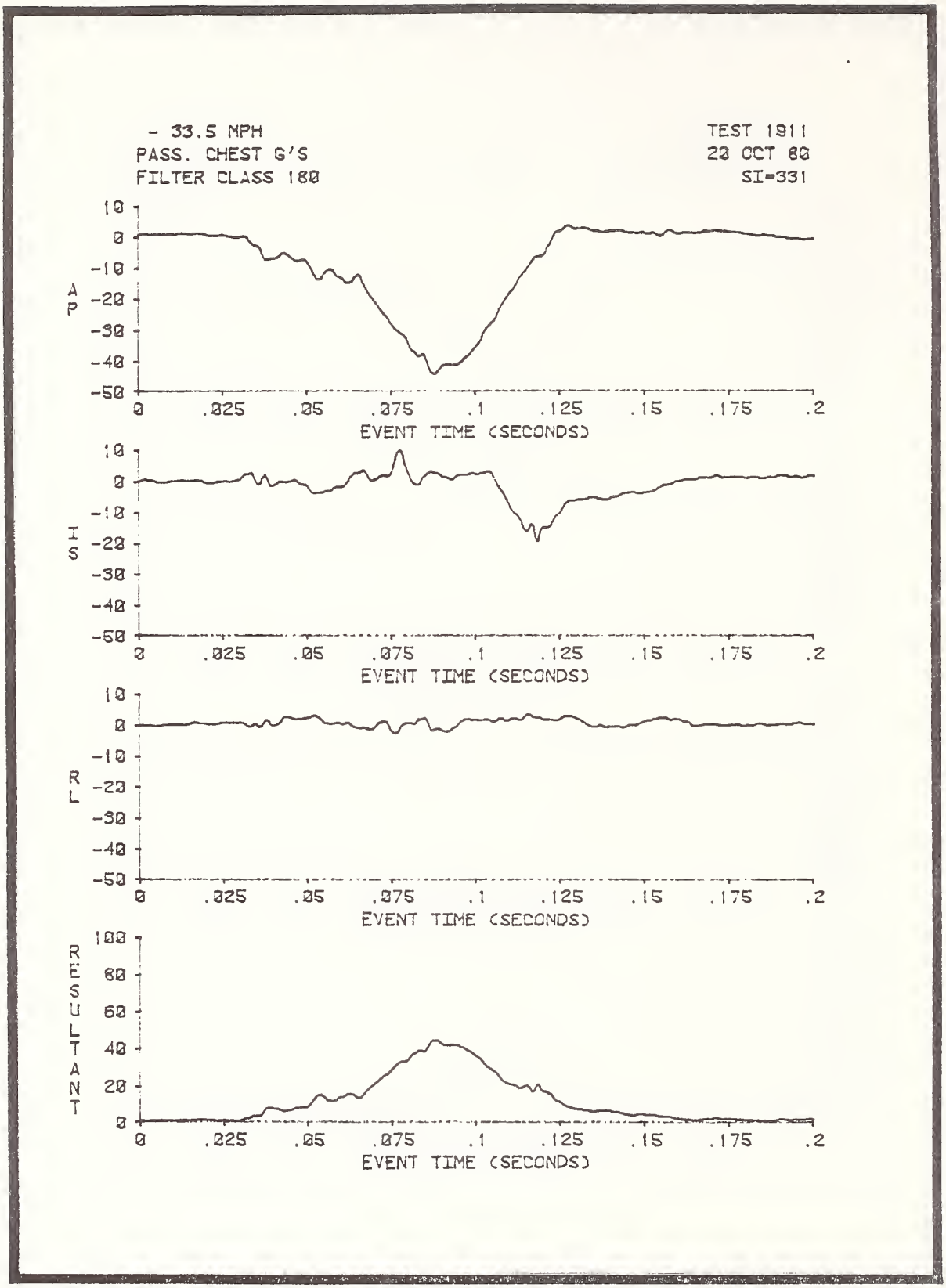
TEST 1902
8 OCT 30

40.3 mph

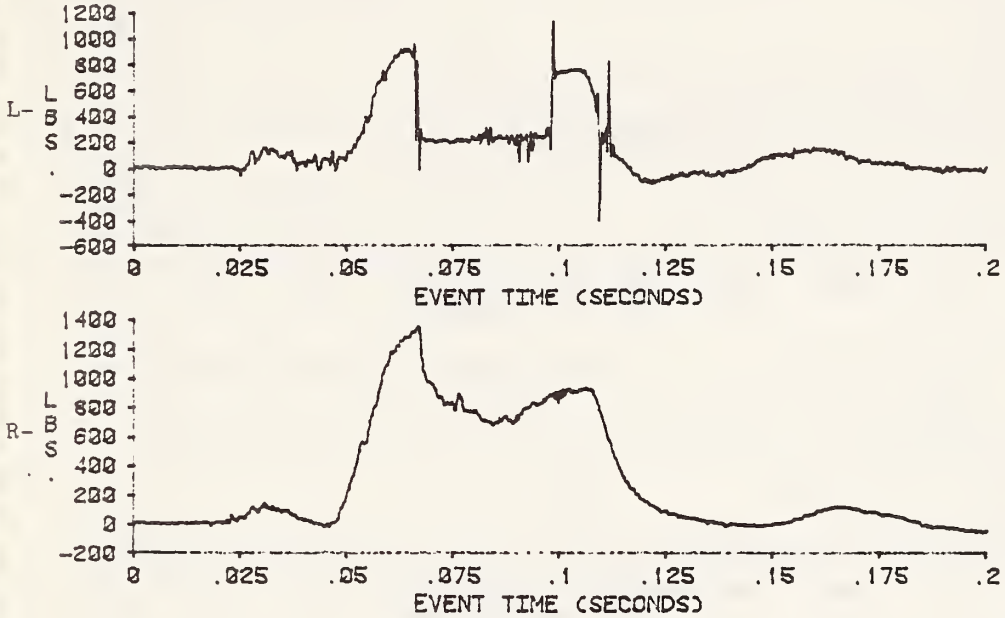



- 40.3 MPH
SLED AP
FILTER CLASS 180
TEST 1902
8 OCT 80
G'S
5
0
-5
-10
-15
-20
-25
-30
-35
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)

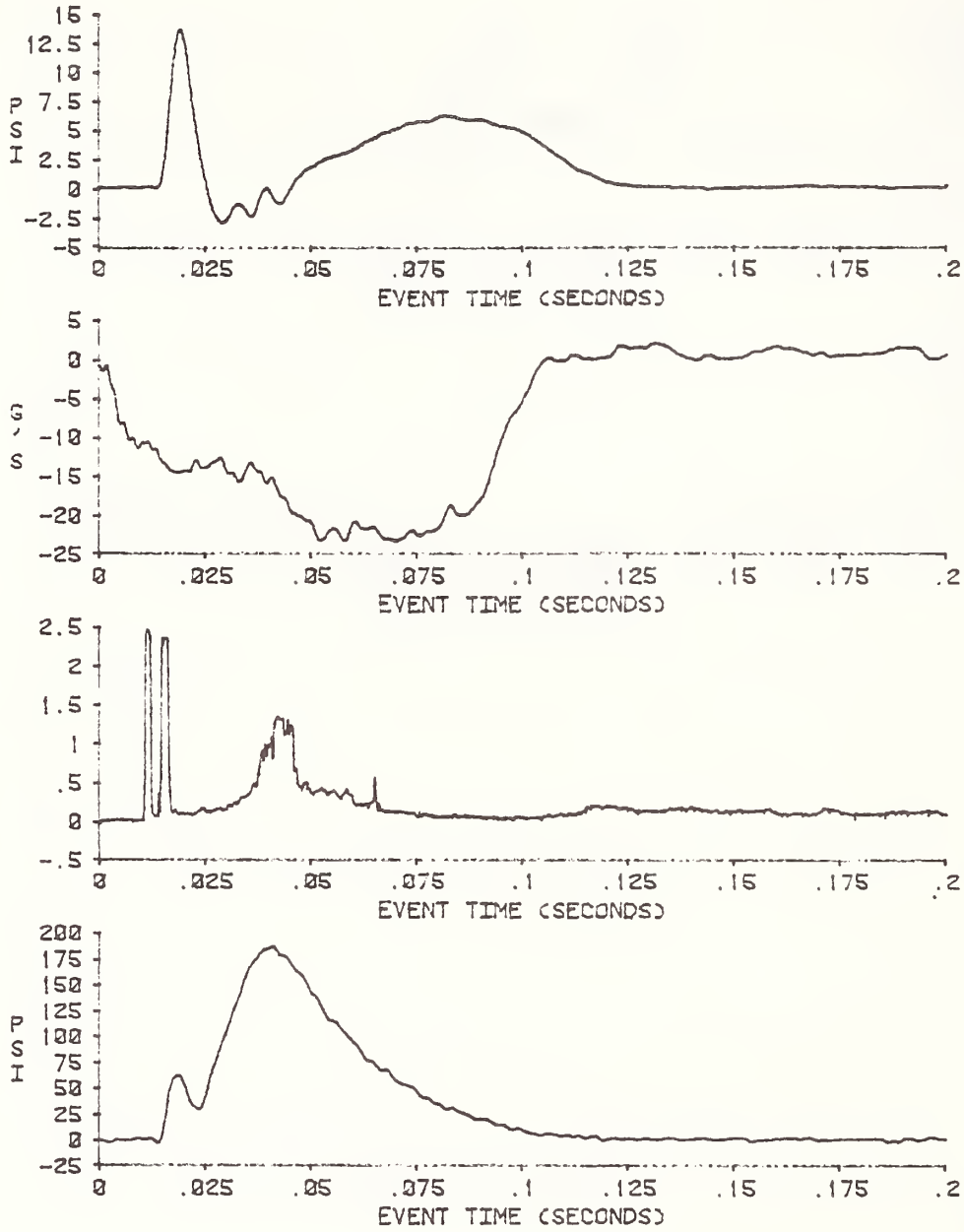

- 33.5 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=377 FROM .068 TO .1054 SECONDS
SI=449
TEST 1911
20 OCT 80
A P
I S
R L
RESULTANT
30
20
10
0
-10
-20
-30
-40
-50
-60
120
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

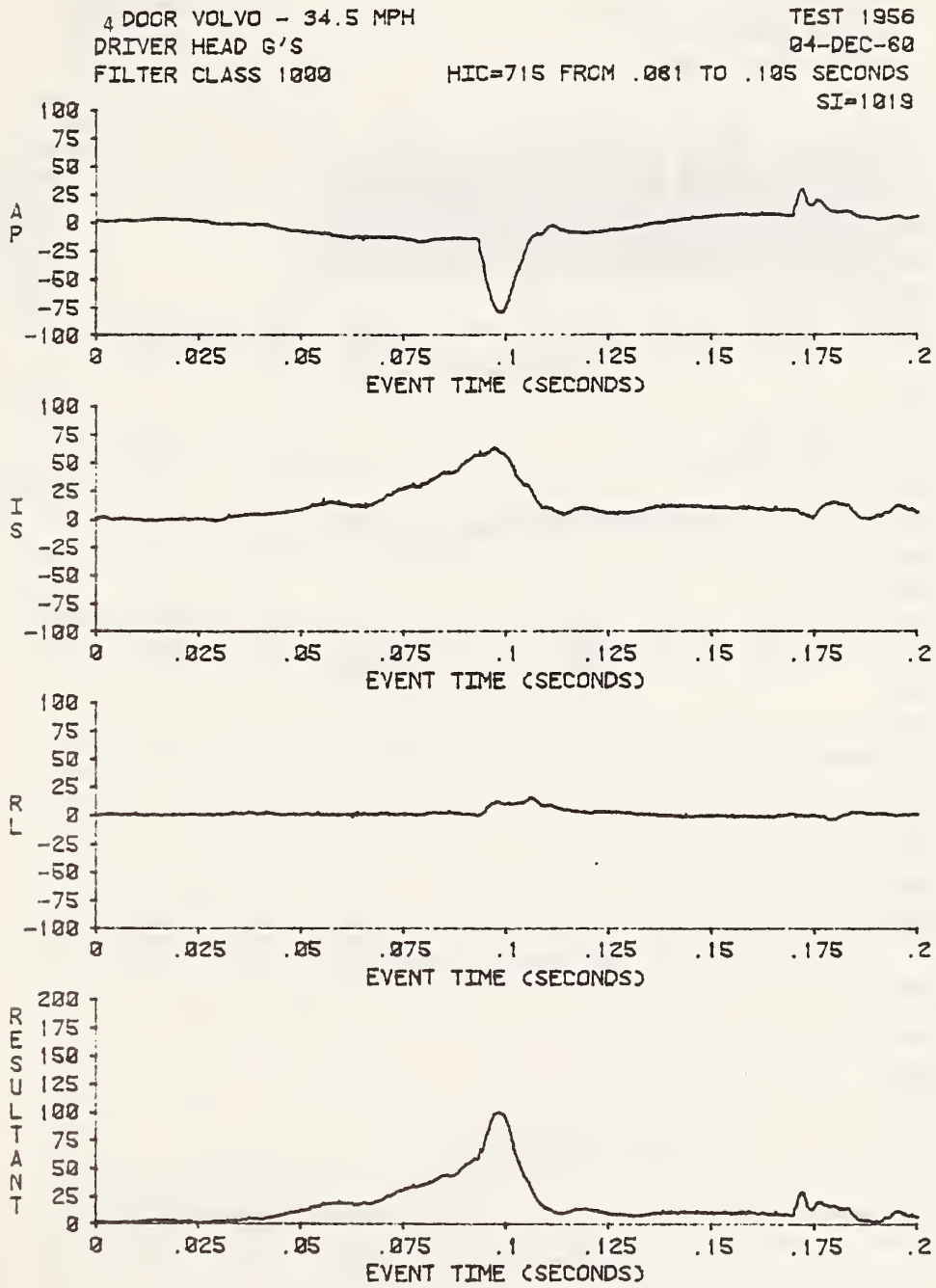

- 33.5 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1911
20 OCT 80
SI=331
AP
HS
RL
RESULTANT
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

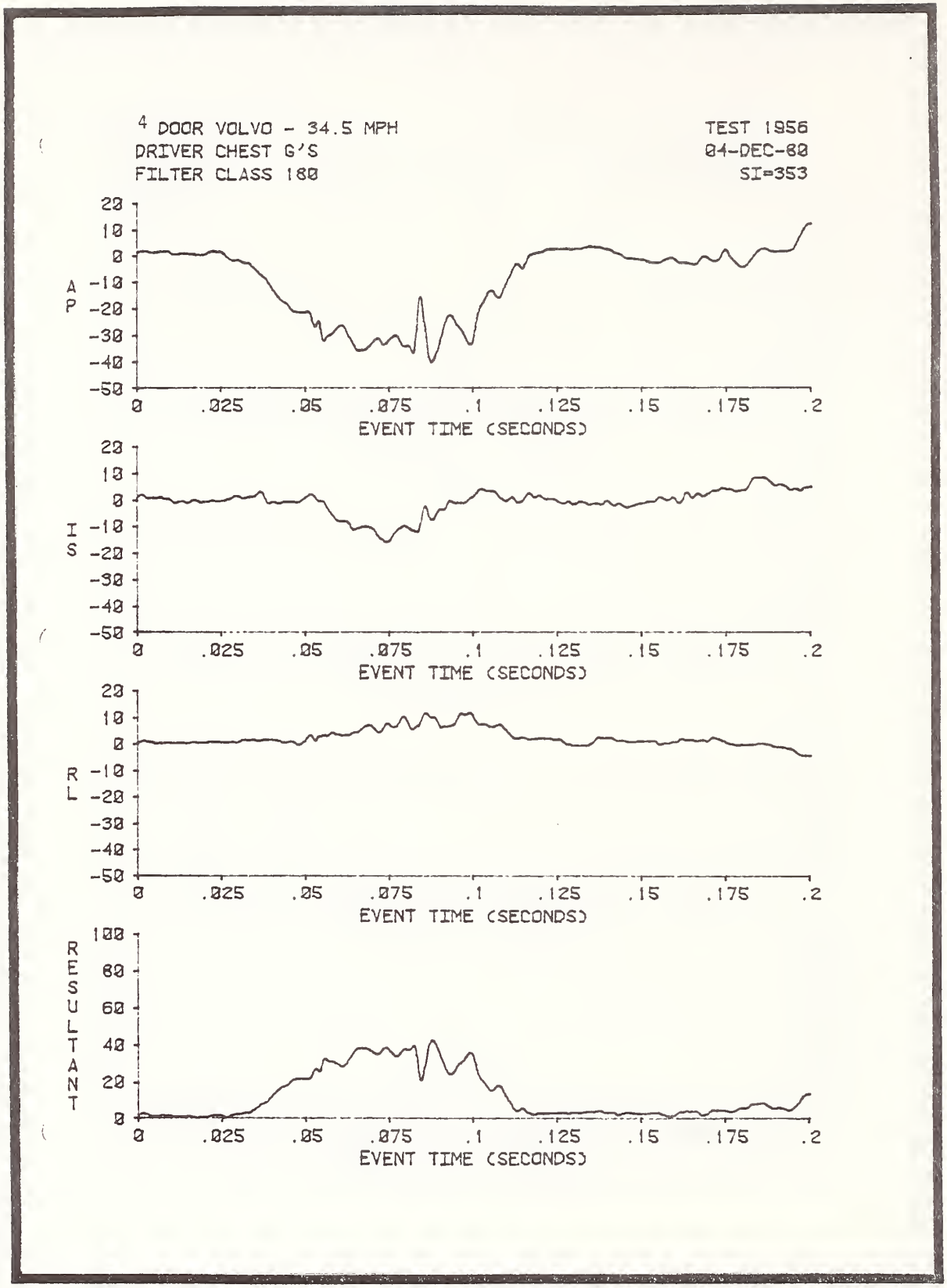
TEST 1911
F.C. 600
L/R FEMUR



TEST 1911
F.C. 180 AIRBAG PRESSURE
F.C. 180 SLED ACCELERATION
F.C. 1000 SQUIB CURRENT
F.C. 180 DIFFUSER PRESSURE

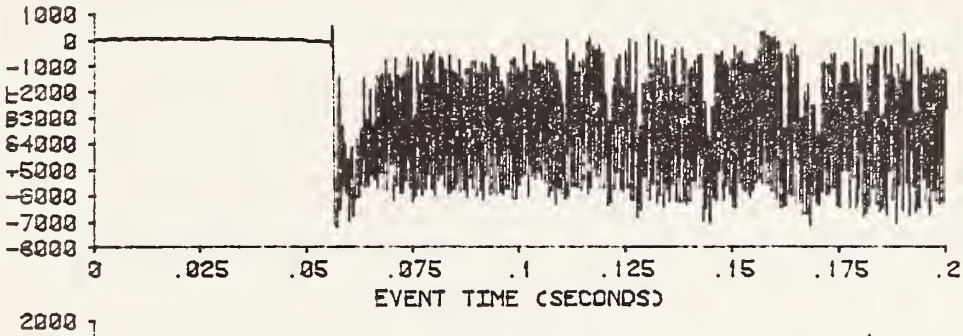


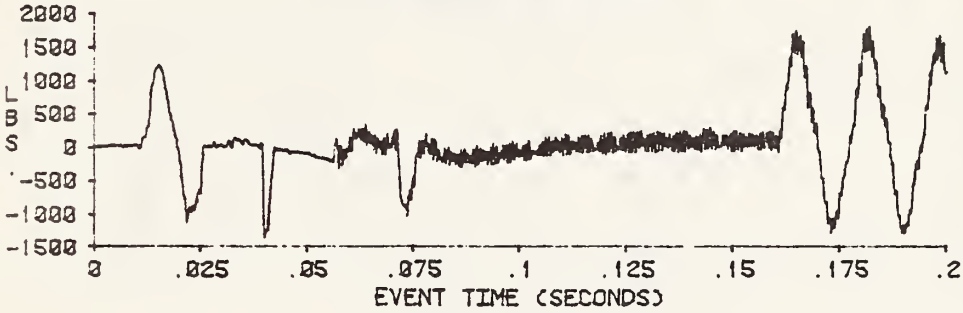

4 DOOR VOLVO - 34.5 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=715 FROM .061 TO .105 SECONDS
TEST 1956
04-DEC-60
SI=1019
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)


4 DOOR VOLVO - 34.5 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1956
04-DEC-80
SI=353
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

4 DOOR VOLVO - 34.5 MPH
DRIVER LEFT FEMUR
DRIVER RIGHT FEMUR
FILTER CLASS 600

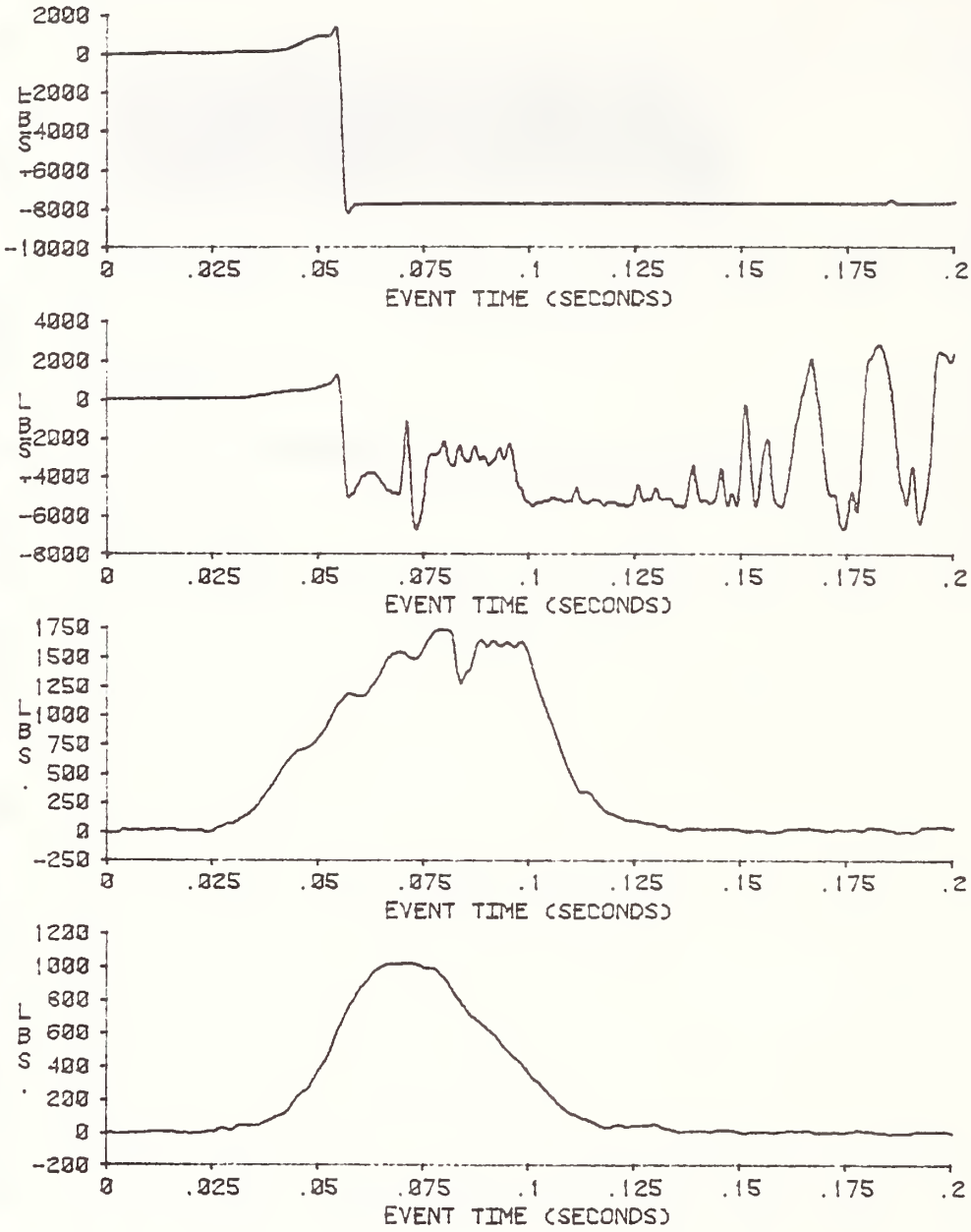
TEST 1956
04 DEC 80





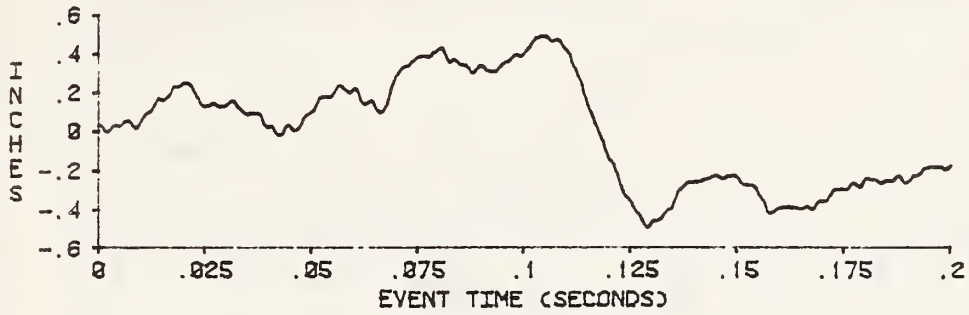
4 DOOR VOLVO -34.5
PASS. R UPPER BELT LOAD
PASS. L LOWER BELT LOAD
DRIVER L UPPER BELT LOAD
DRIVER L LOWER BELT LOAD
FILTER CLASS 180

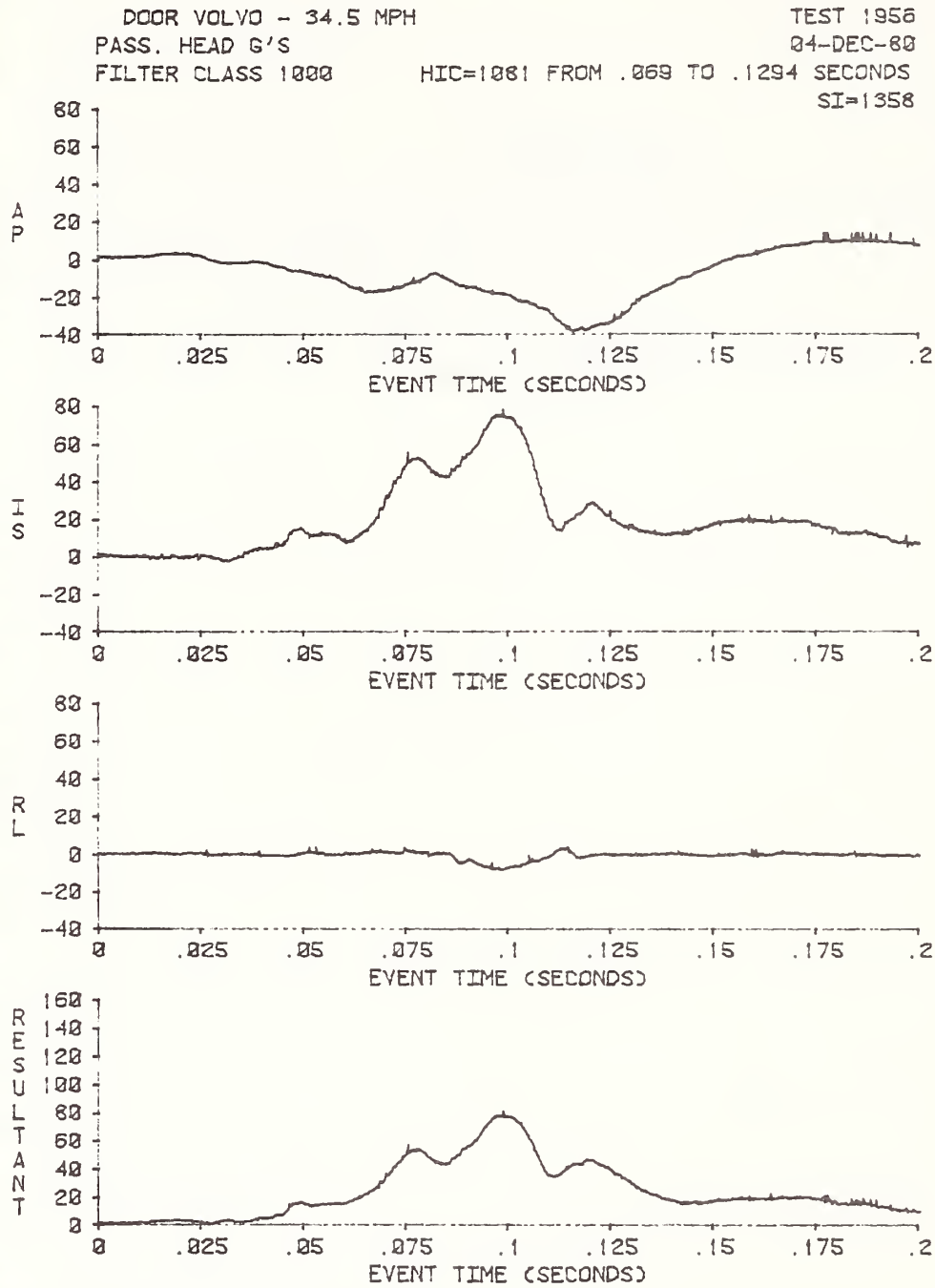
TEST 1956
04 DEC 80

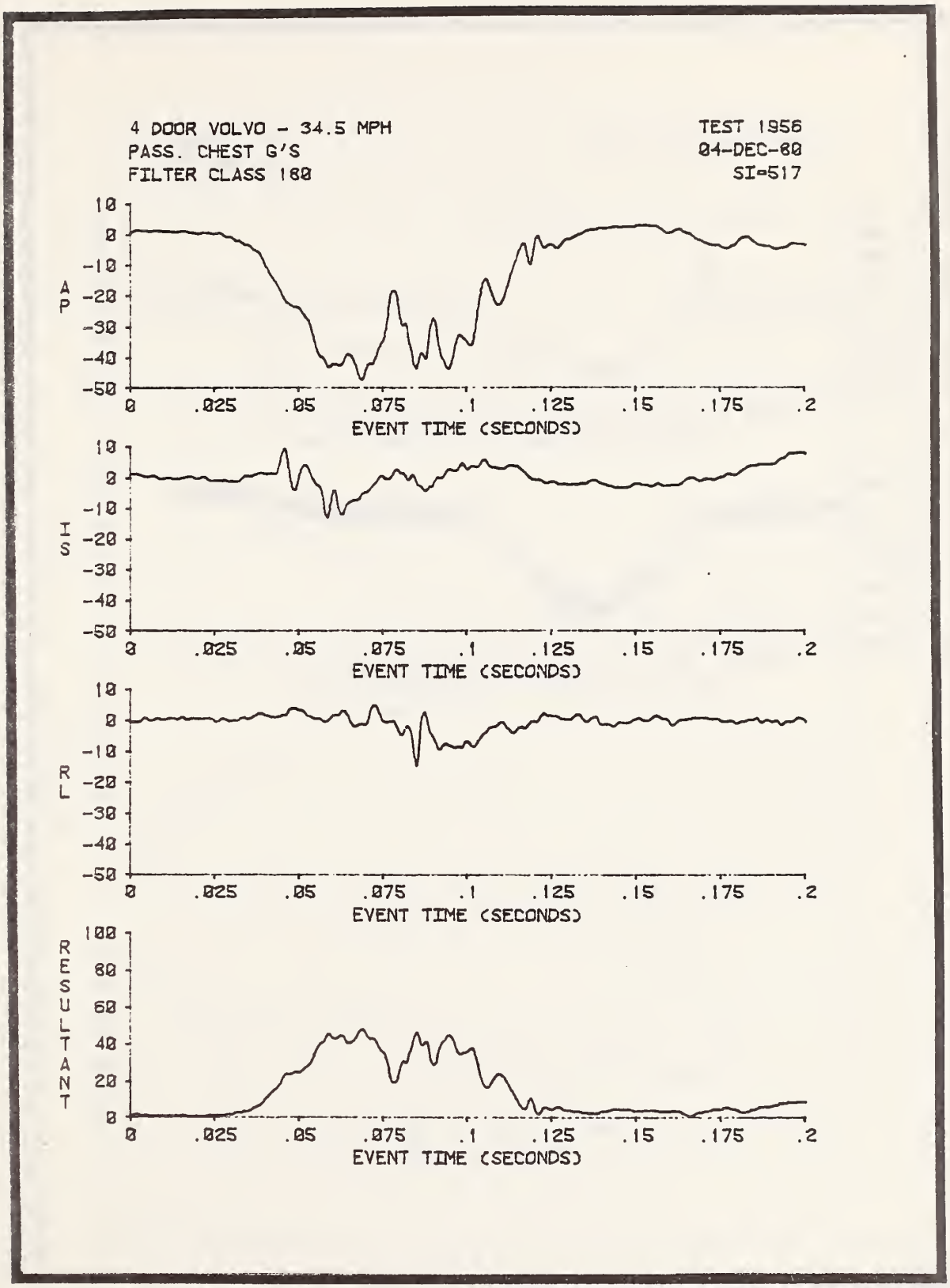


4 DOOR VOLVO -34.5 MPH
COLUMN DEFLECTION
FILTER CLASS 180

TEST 1956
04 DEC 80

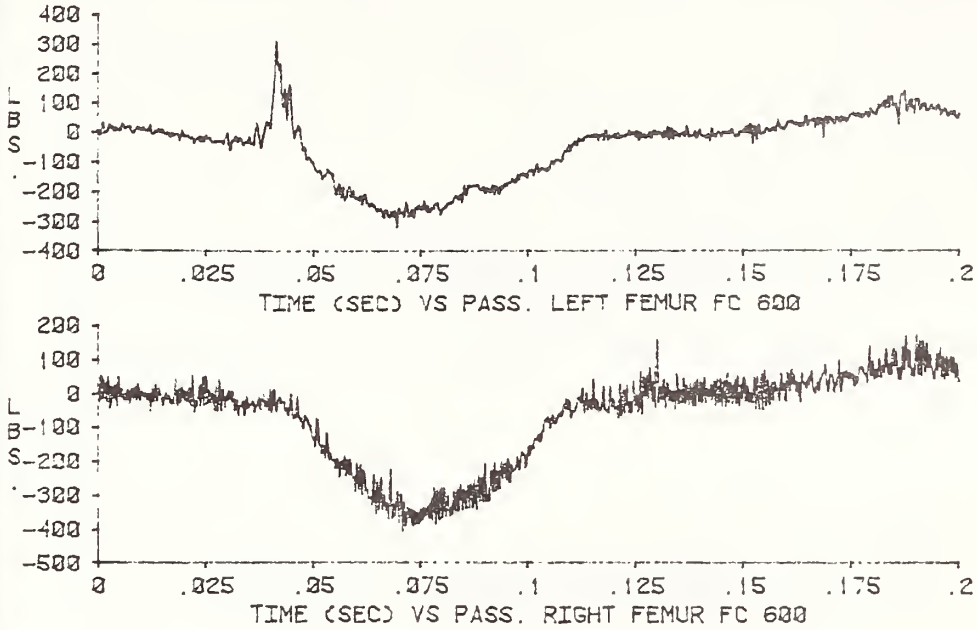


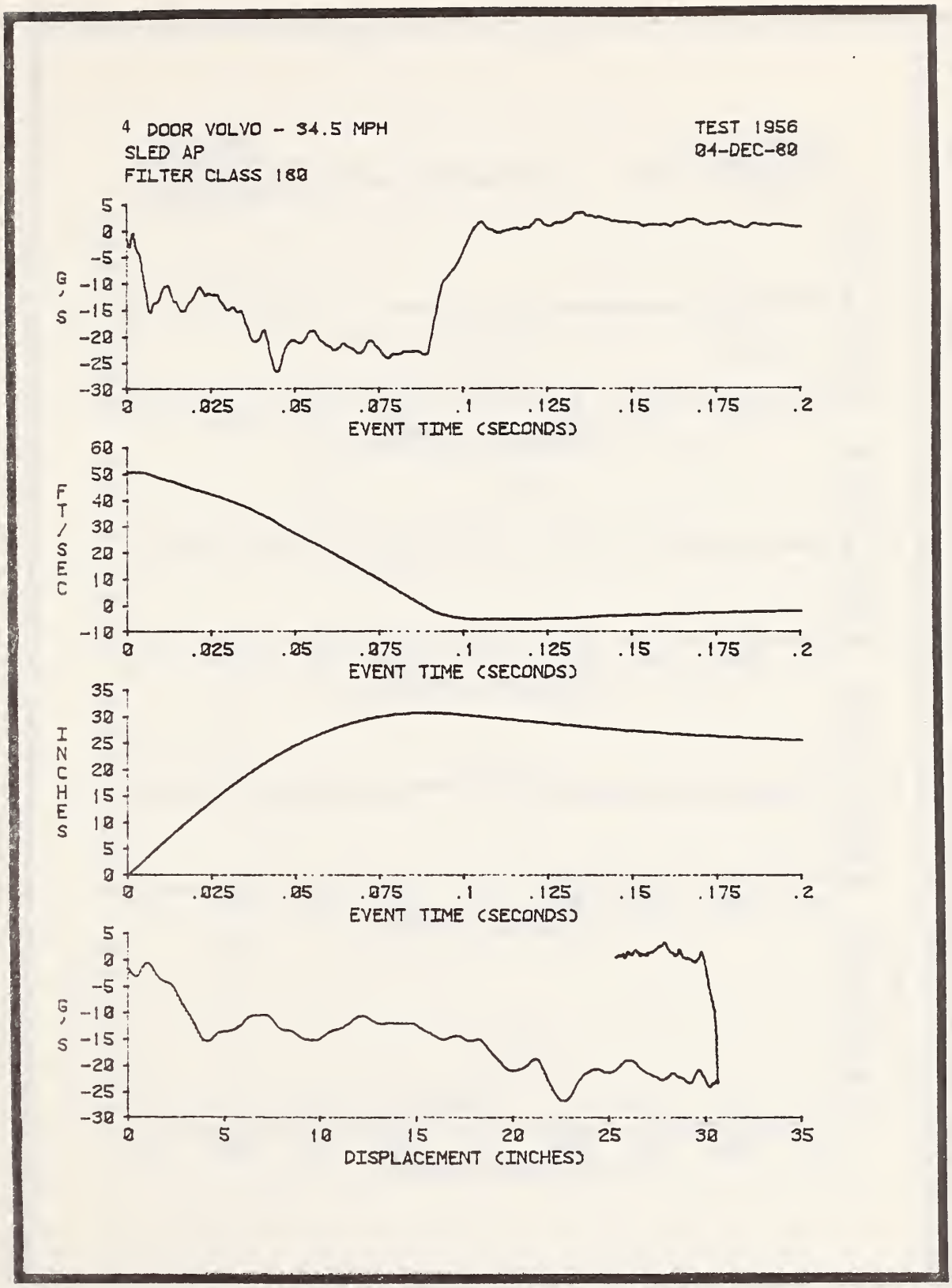

DOOR VOLVO - 34.5 MPH
TEST 1956
PASS. HEAD G'S
04-DEC-80
FILTER CLASS 1000
HIC=1061 FROM .069 TO .1294 SECONDS
SI=1358
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

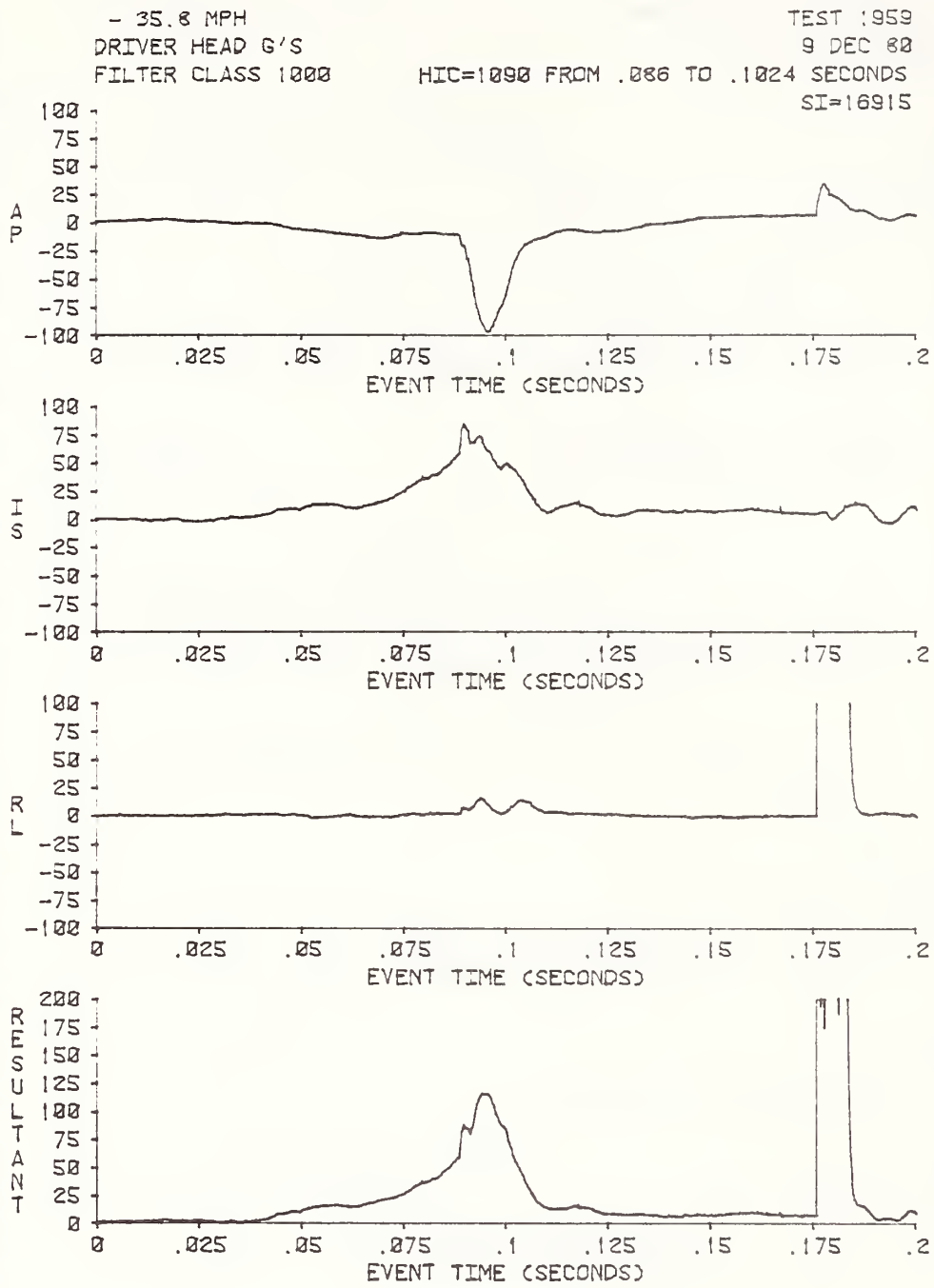

4 DOOR VOLVO - 34.5 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1956
04-DEC-80
SI=517
AP
IS
RL
RESULTANT
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

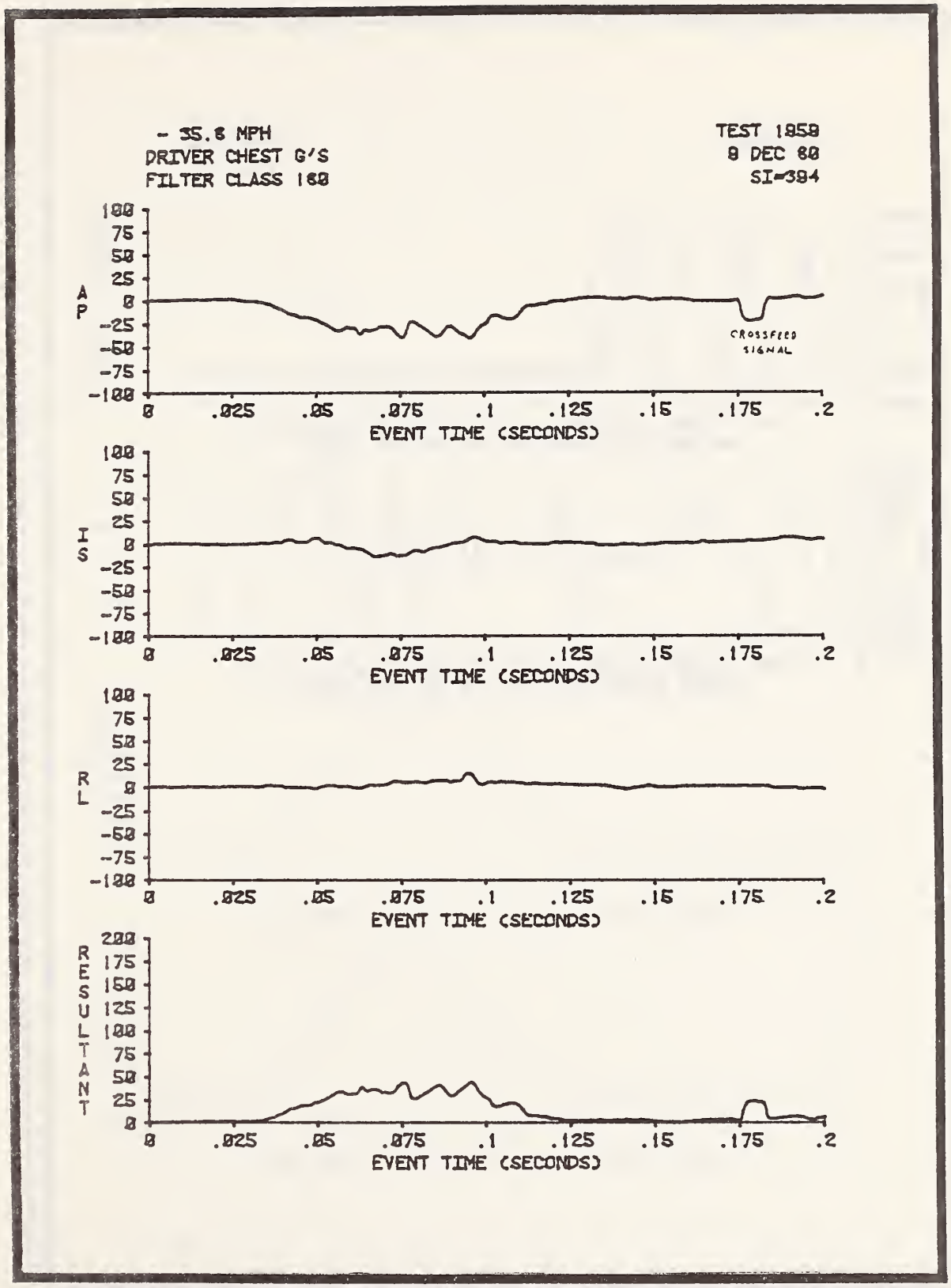
4 DOOR VOLVO - 34.5 MPH

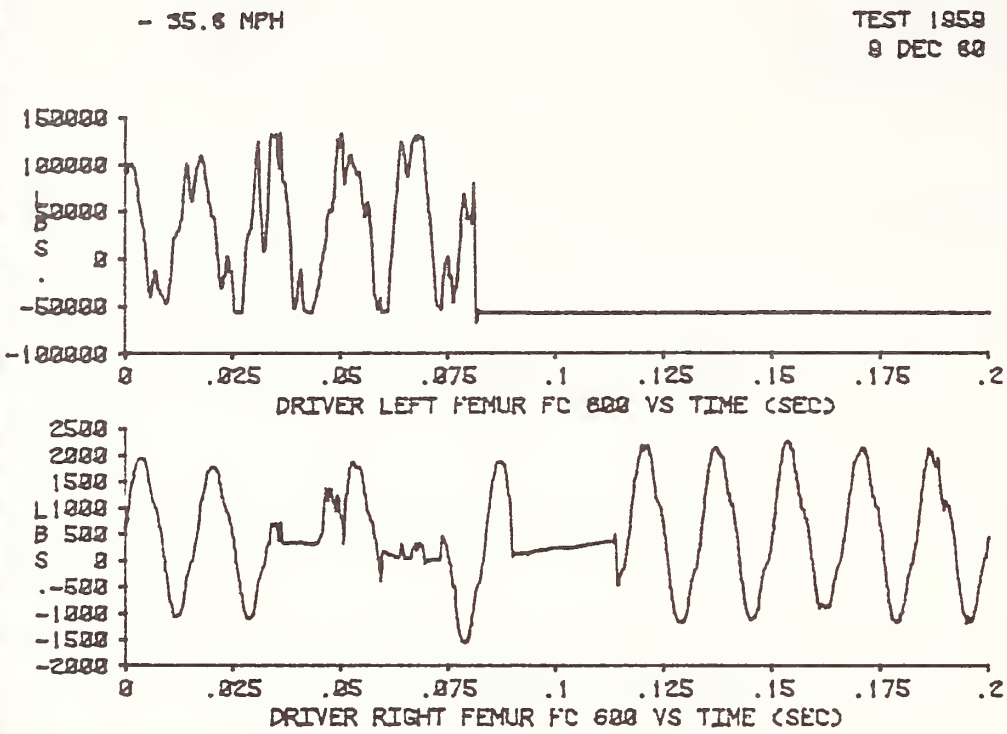
TEST 1956
04-DEC-80

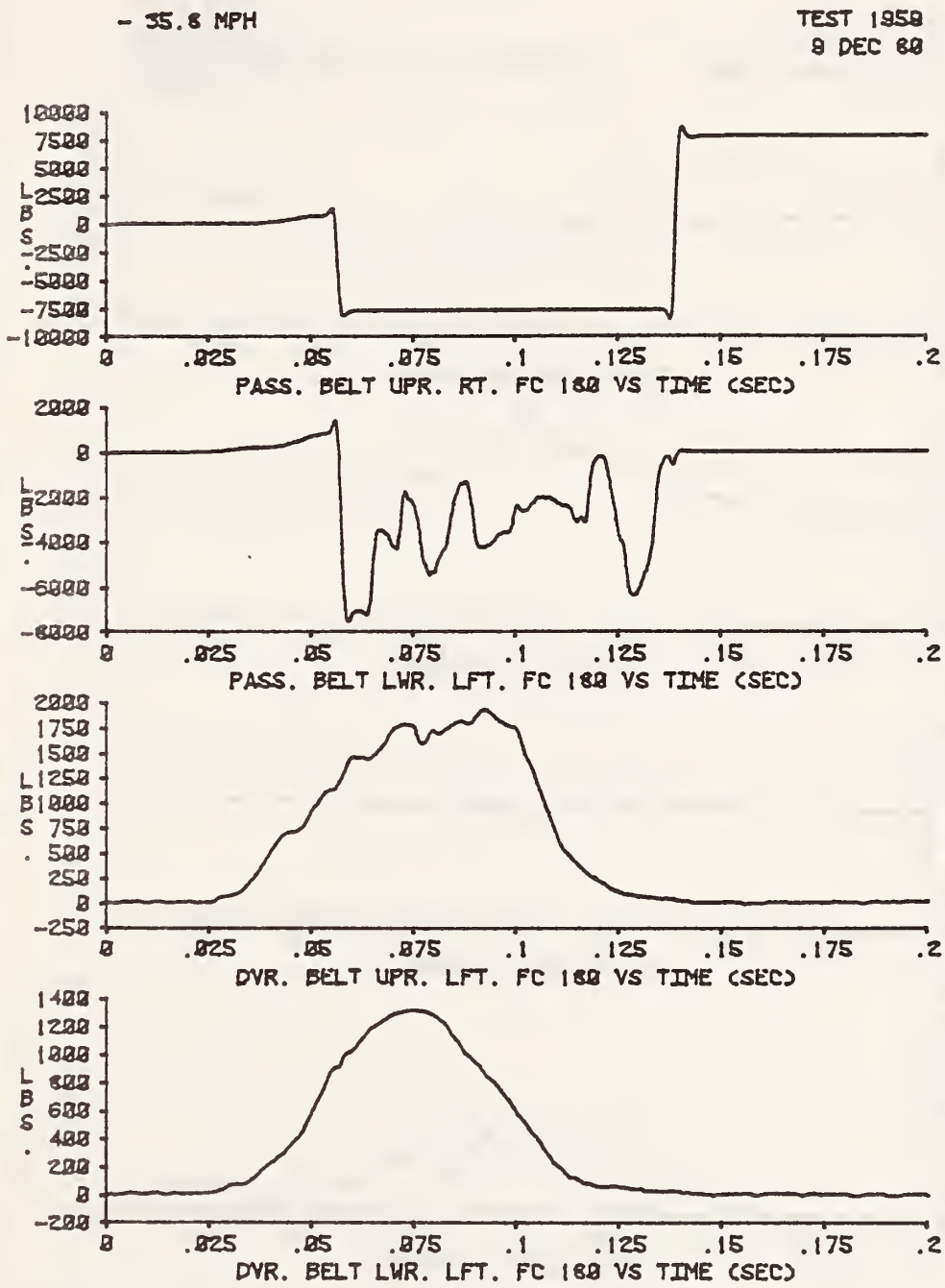


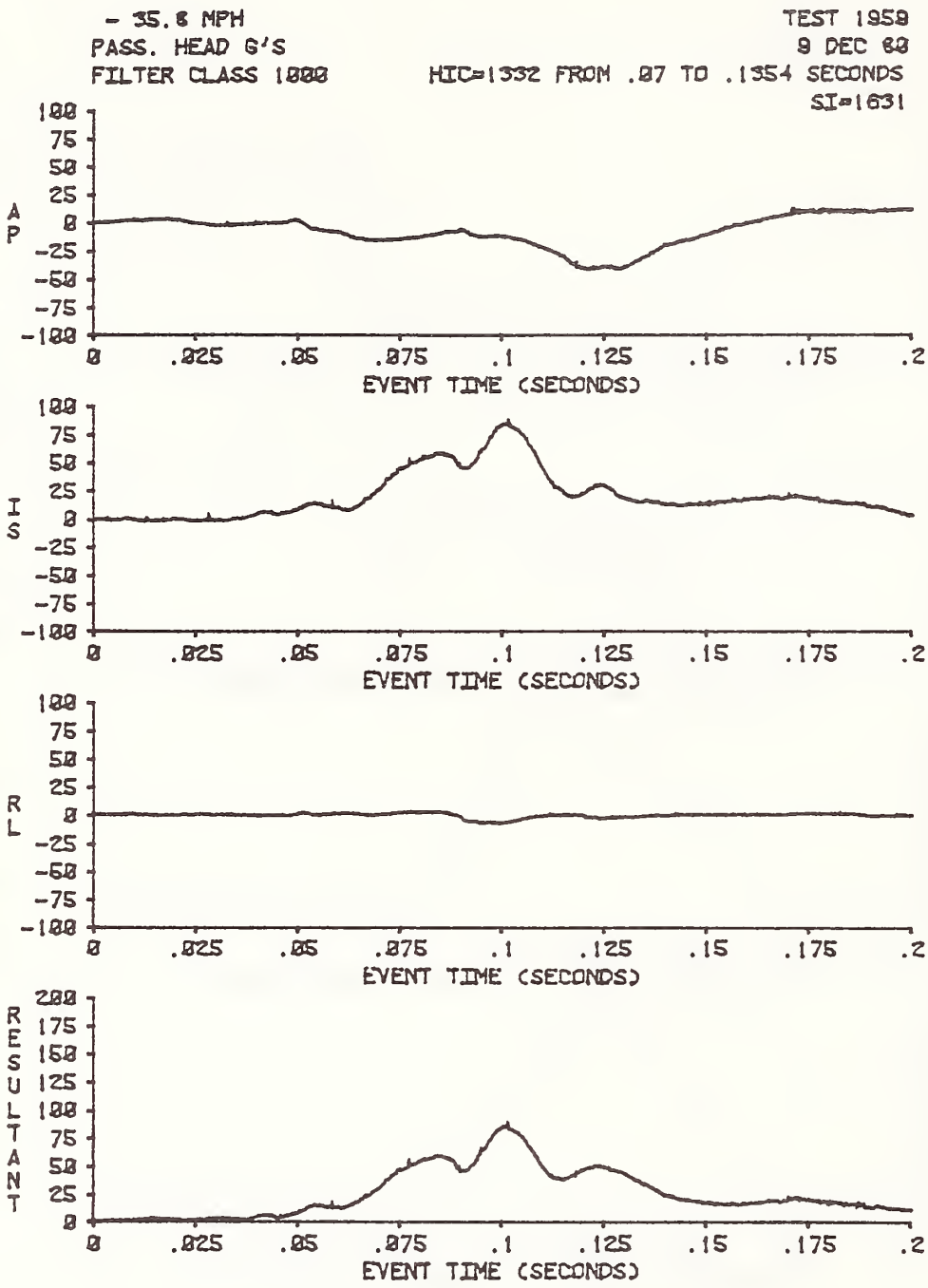

4 DOOR VOLVO - 34.5 MPH
SLED AP
FILTER CLASS 180
TEST 1956
04-DEC-80
G'S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)
G'S
DISPLACEMENT (INCHES)

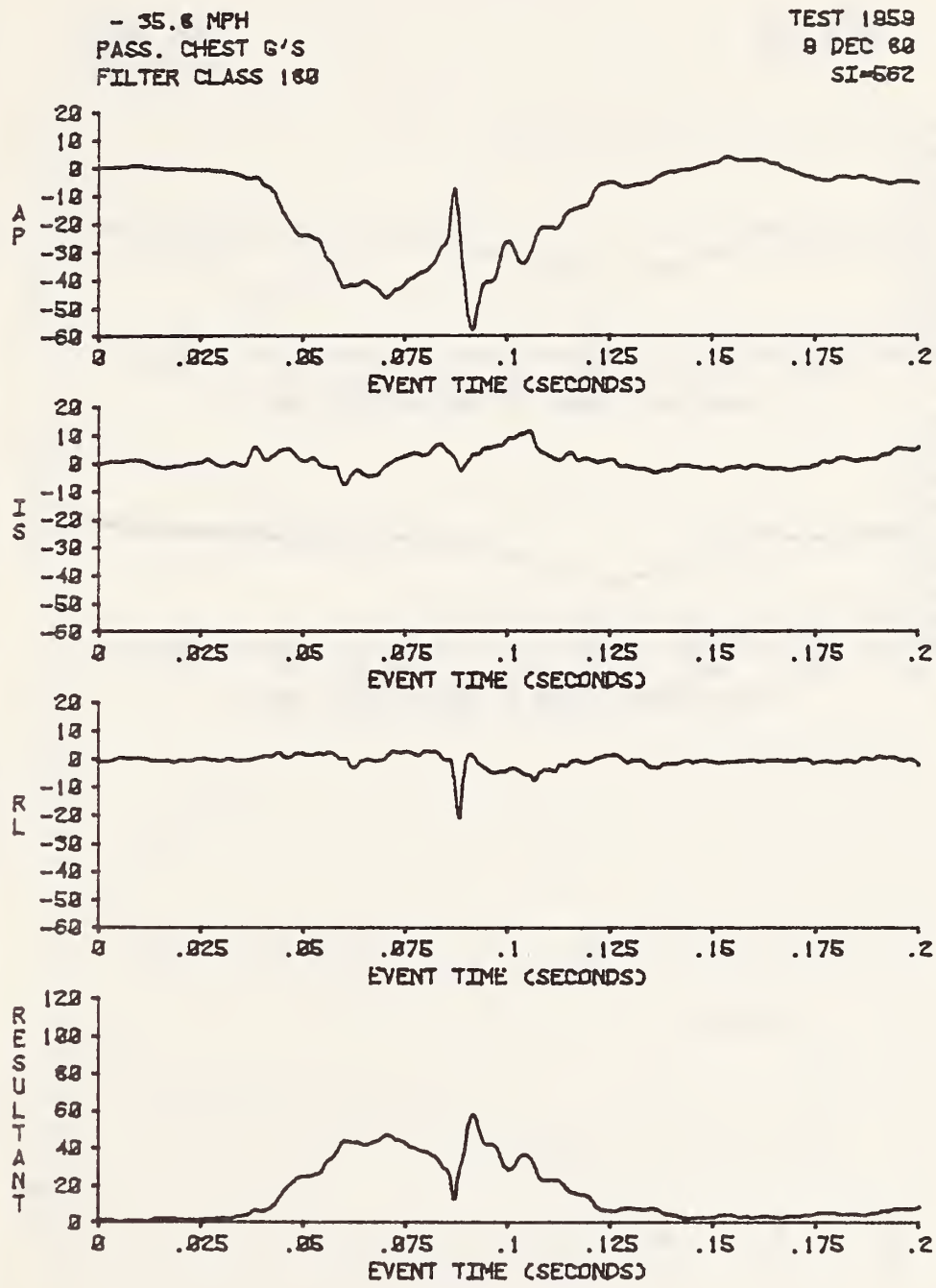

- 35.8 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=1090 FROM .086 TO .1024 SECONDS
TEST 1959
9 DEC 80
SI=16915
AP
IS
LR
RESULTANT
EVENT TIME (SECONDS)

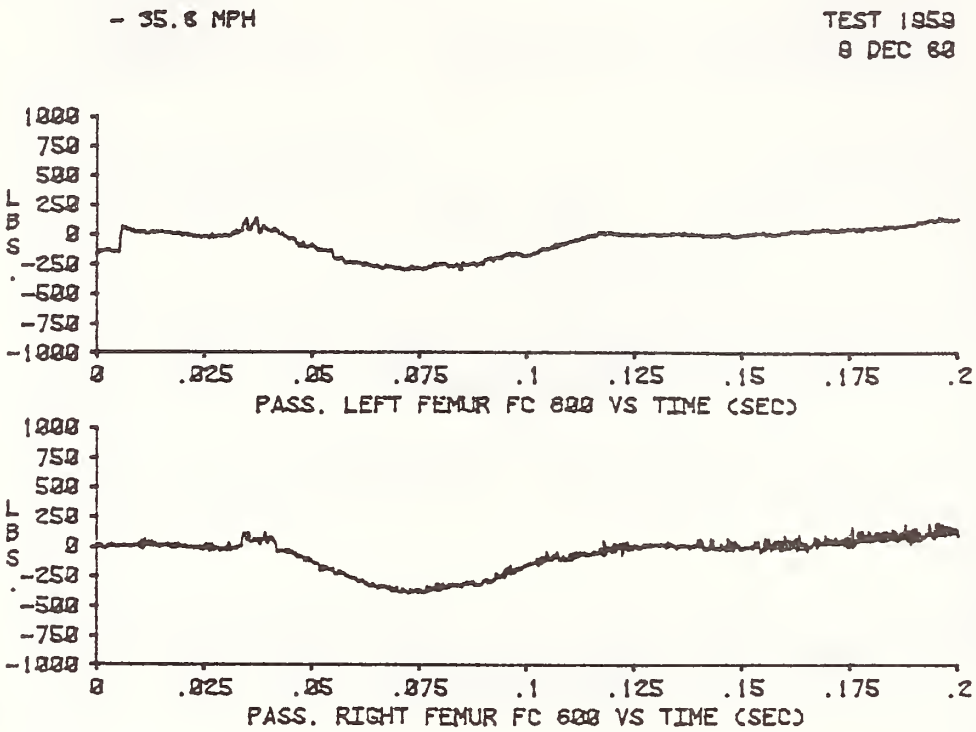

- 35.6 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1858
8 DEC 80
SI=384
AP
CROSSFEED SIGNAL
IS
RL
RESULTANT
EVENT TIME (SECONDS)

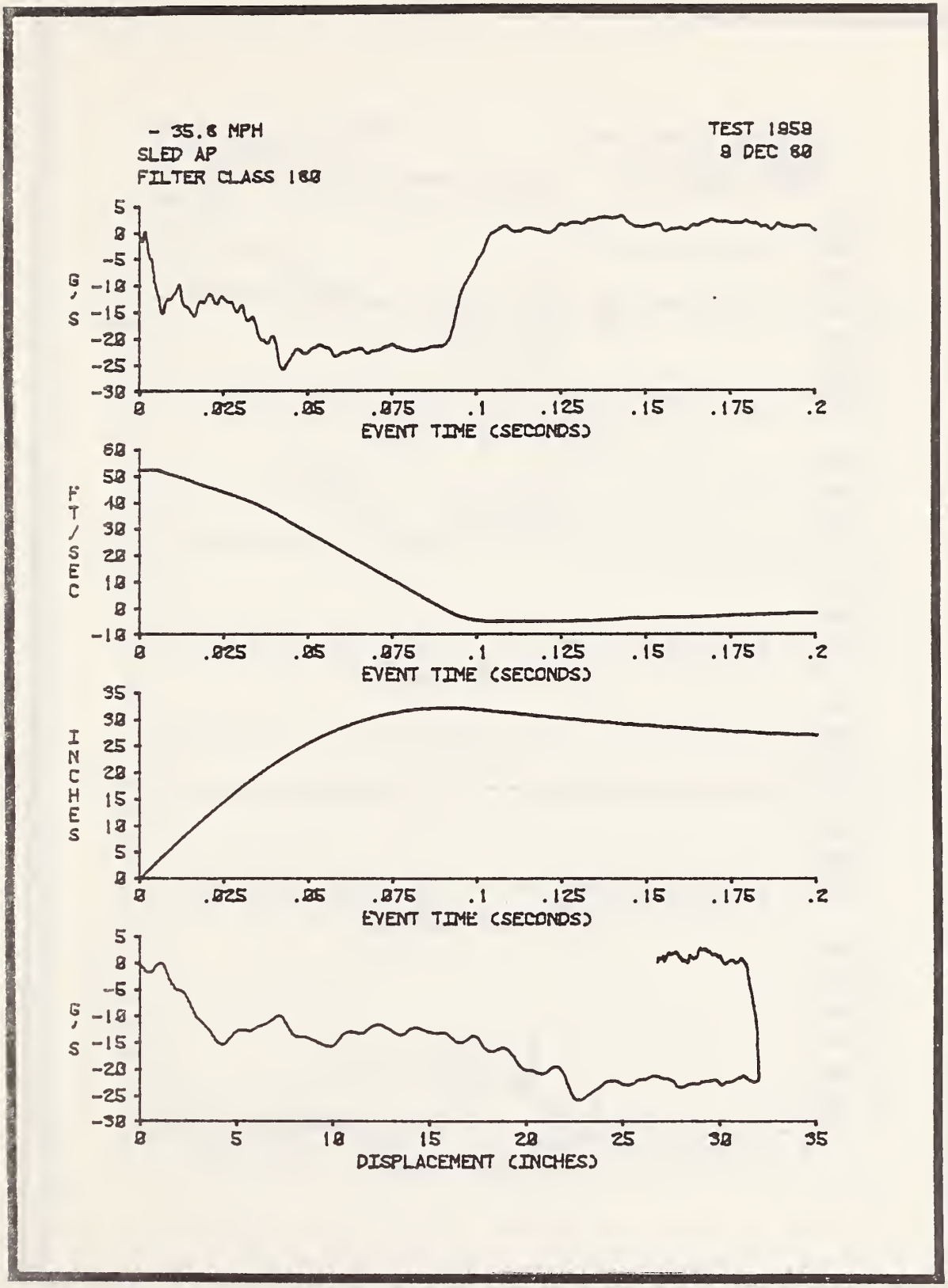

- 35.6 MPH
TEST 1959
9 DEC 60
150000
100000
50000
0
-50000
-100000
LBS
0
.025
.05
.075
.1
.125
.15
.175
.2
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
LBS
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)

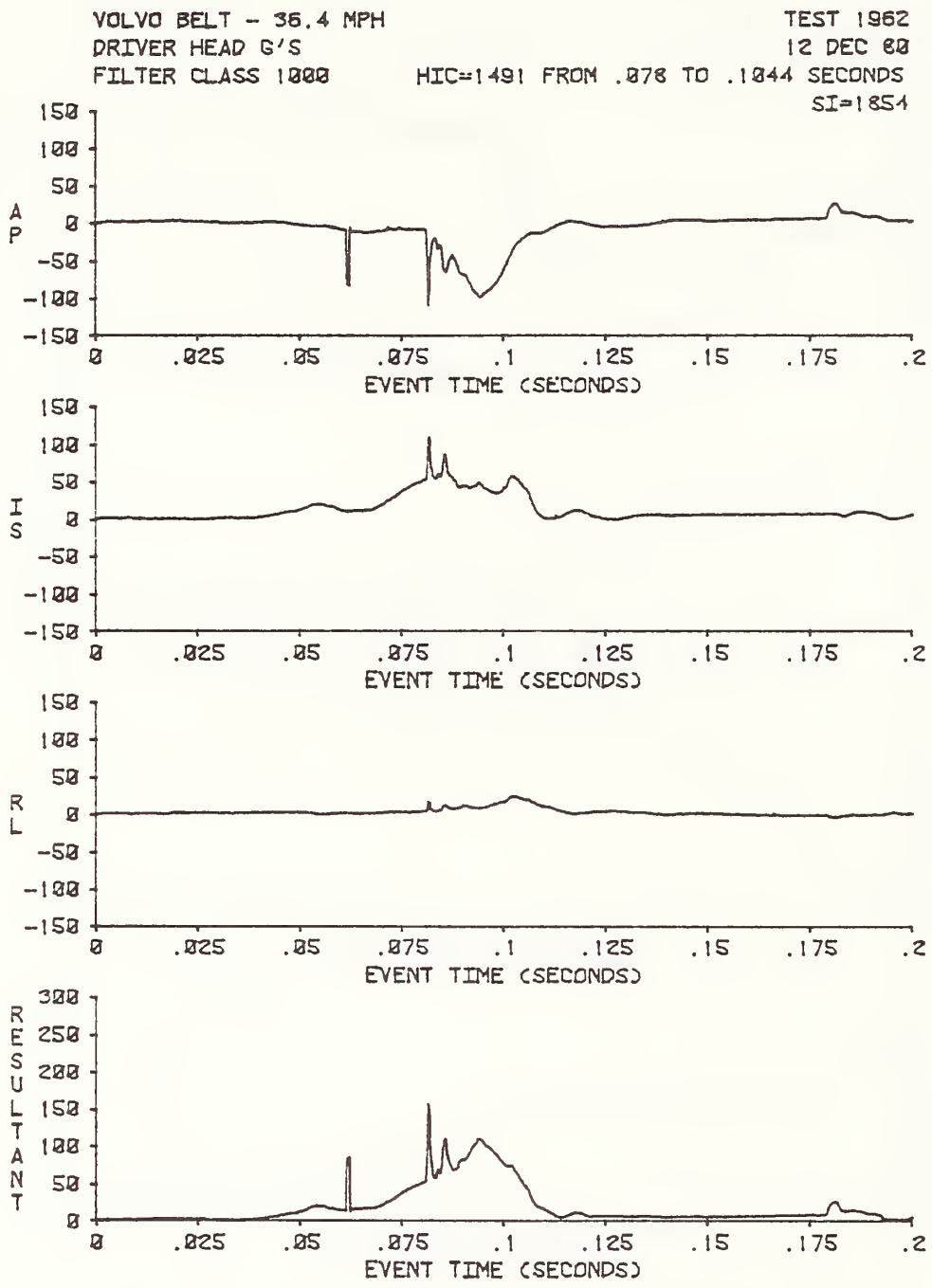

- 35.8 MPH
TEST 1958
9 DEC 80
LBS.
PASS. BELT UPR. RT. FC 180 VS TIME (SEC)
PASS. BELT LWR. LFT. FC 180 VS TIME (SEC)
DVR. BELT UPR. LFT. FC 180 VS TIME (SEC)
DVR. BELT LWR. LFT. FC 180 VS TIME (SEC)

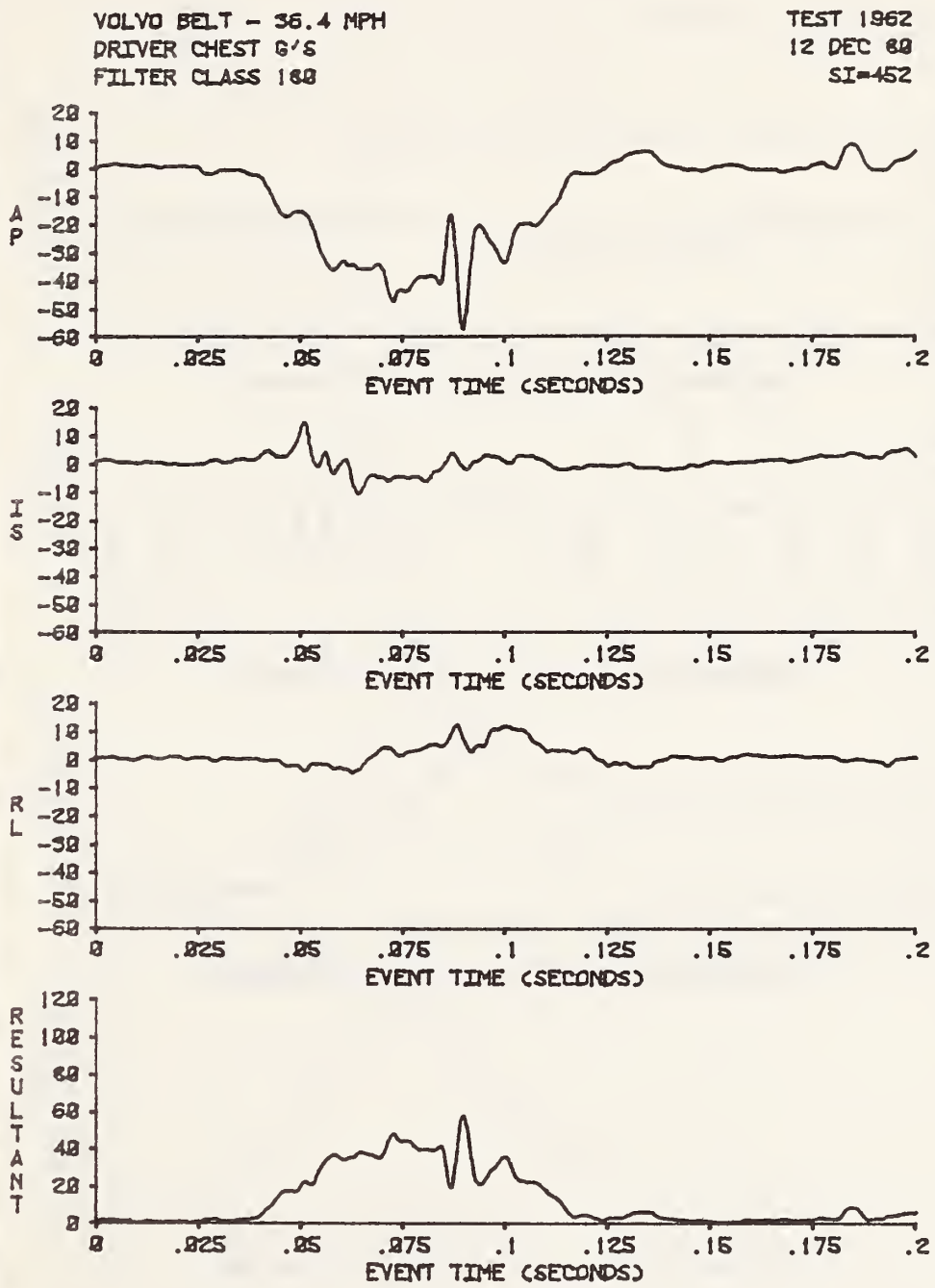

- 35.6 MPH
PASS. HEAD G'S
FILTER CLASS 1000
TEST 1959
9 DEC 80
HIC=1332 FROM .07 TO .1354 SECONDS
SI=1631
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)


- 35.6 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1859
8 DEC 80
SI=662
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)


- 35.8 MPH
TEST 1959
8 DEC 80
1000
750
500
250
0
-250
-500
-750
-1000
LBS
0
.025
.05
.075
.1
.125
.15
.175
.2
PASS. LEFT FEMUR FC 800 VS TIME (SEC)
PASS. RIGHT FEMUR FC 600 VS TIME (SEC)

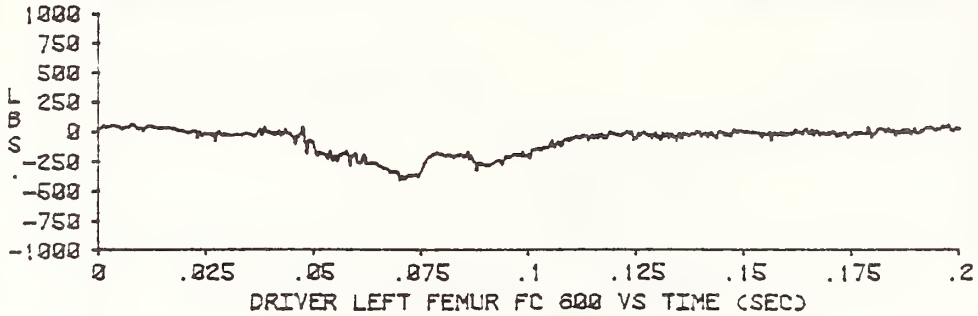

- 35.6 MPH
SLED AP
FILTER CLASS 180
TEST 1959
8 DEC 80
G'S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)
G'S
DISPLACEMENT (INCHES)


VOLVO BELT - 36.4 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=1491 FROM .076 TO .1044 SECONDS
SI=1854
TEST 1962
12 DEC 80
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

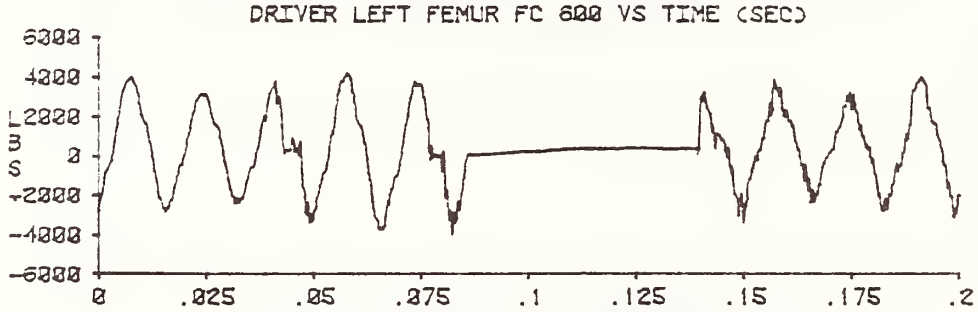

VOLVO BELT - 36.4 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1962
12 DEC 80
SI=452
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

VOLVO BELT - 36.4 MPH

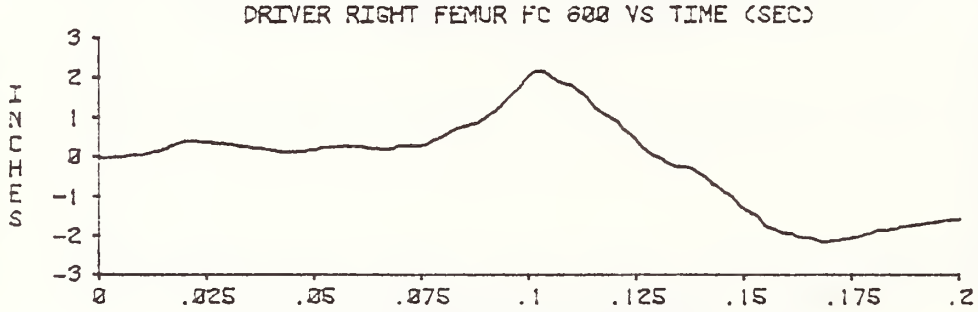
TEST 1962
12 DEC 80



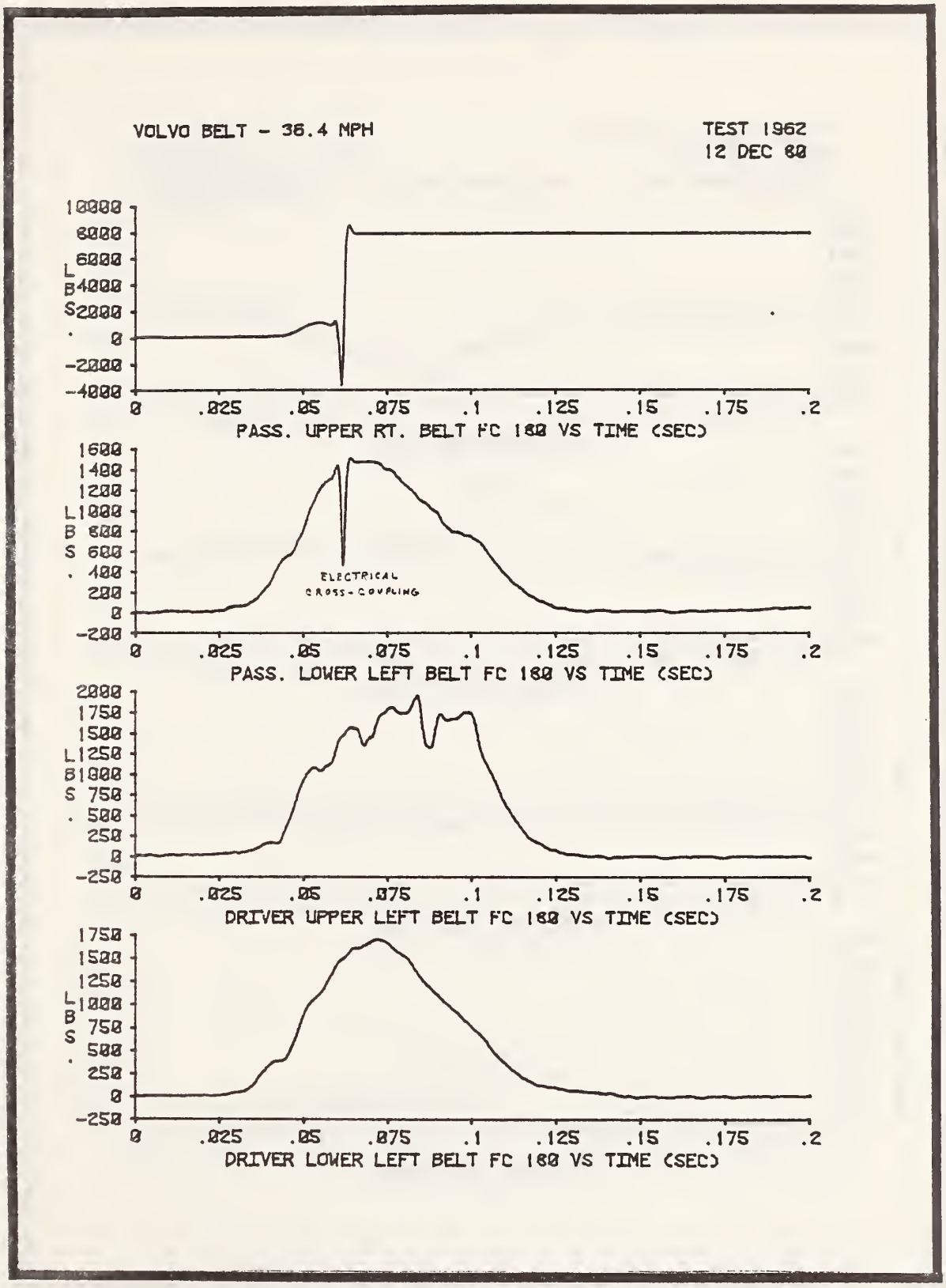
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)

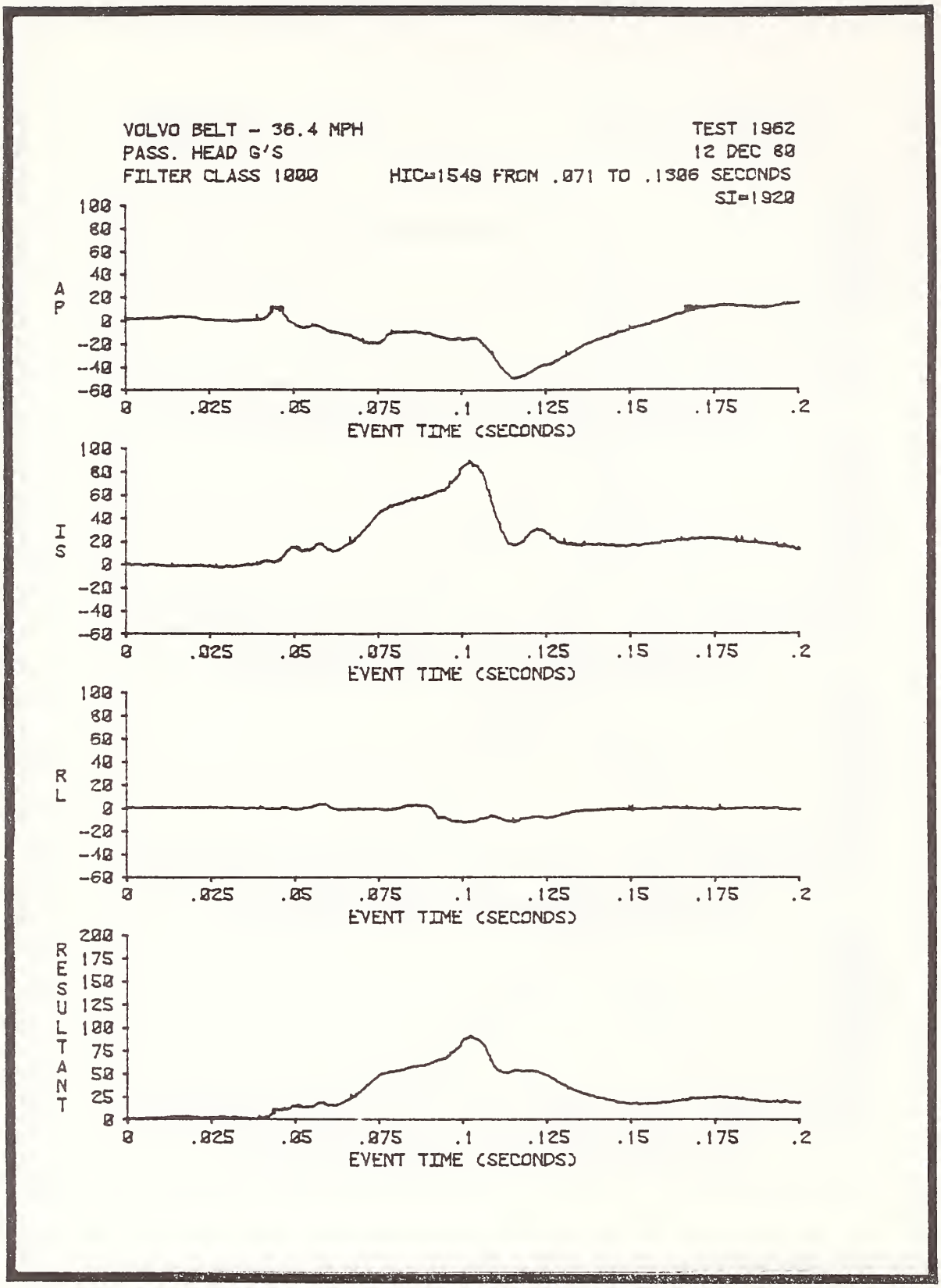


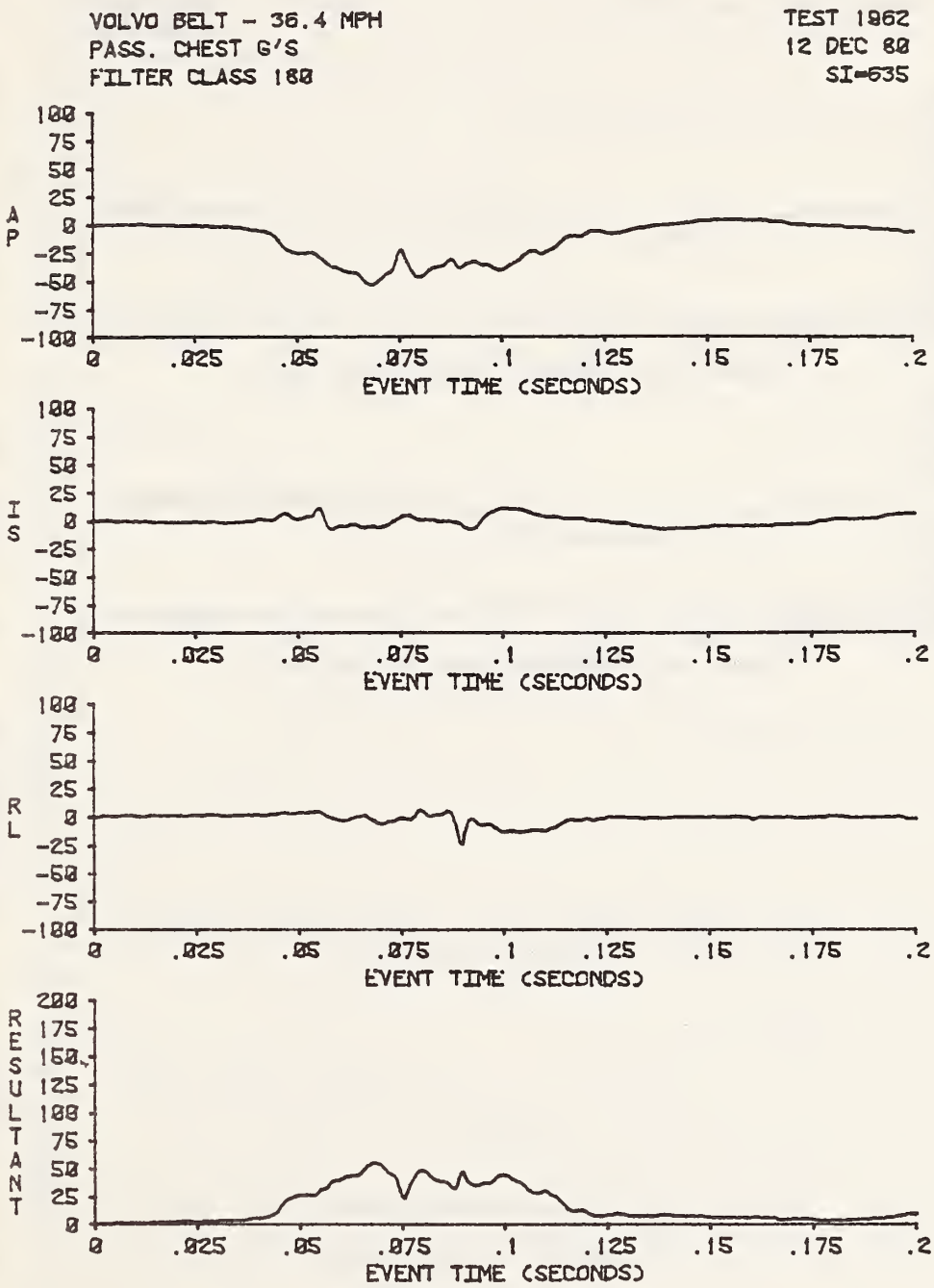
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)



COLUMN DEFLECTION FC 180 VS TIME (SEC)

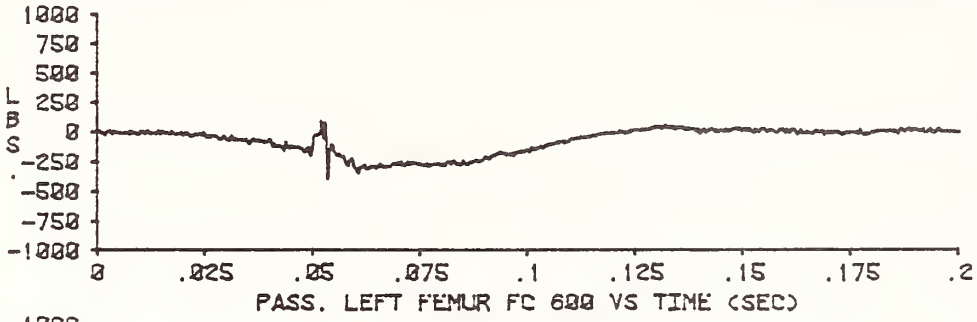

VOLVO BELT - 36.4 MPH
TEST 1962
12 DEC 80
LBS.
PASS. UPPER RT. BELT FC 180 VS TIME (SEC)
ELECTRICAL
CROSS-COUPLING
PASS. LOWER LEFT BELT FC 180 VS TIME (SEC)
DRIVER UPPER LEFT BELT FC 180 VS TIME (SEC)
DRIVER LOWER LEFT BELT FC 180 VS TIME (SEC)


VOLVO BELT - 36.4 MPH
TEST 1962
PASS. HEAD G'S
12 DEC 80
FILTER CLASS 1000
HIC=1549 FROM .071 TO .1306 SECONDS
SI=1920
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

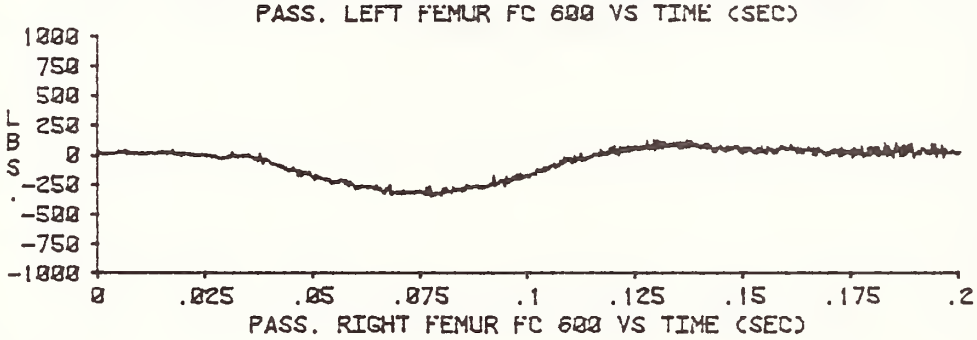

VOLVO BELT - 36.4 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1962
12 DEC 80
SI=635
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
100
75
50
25
0
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

VOLVO BELT - 36.4 MPH

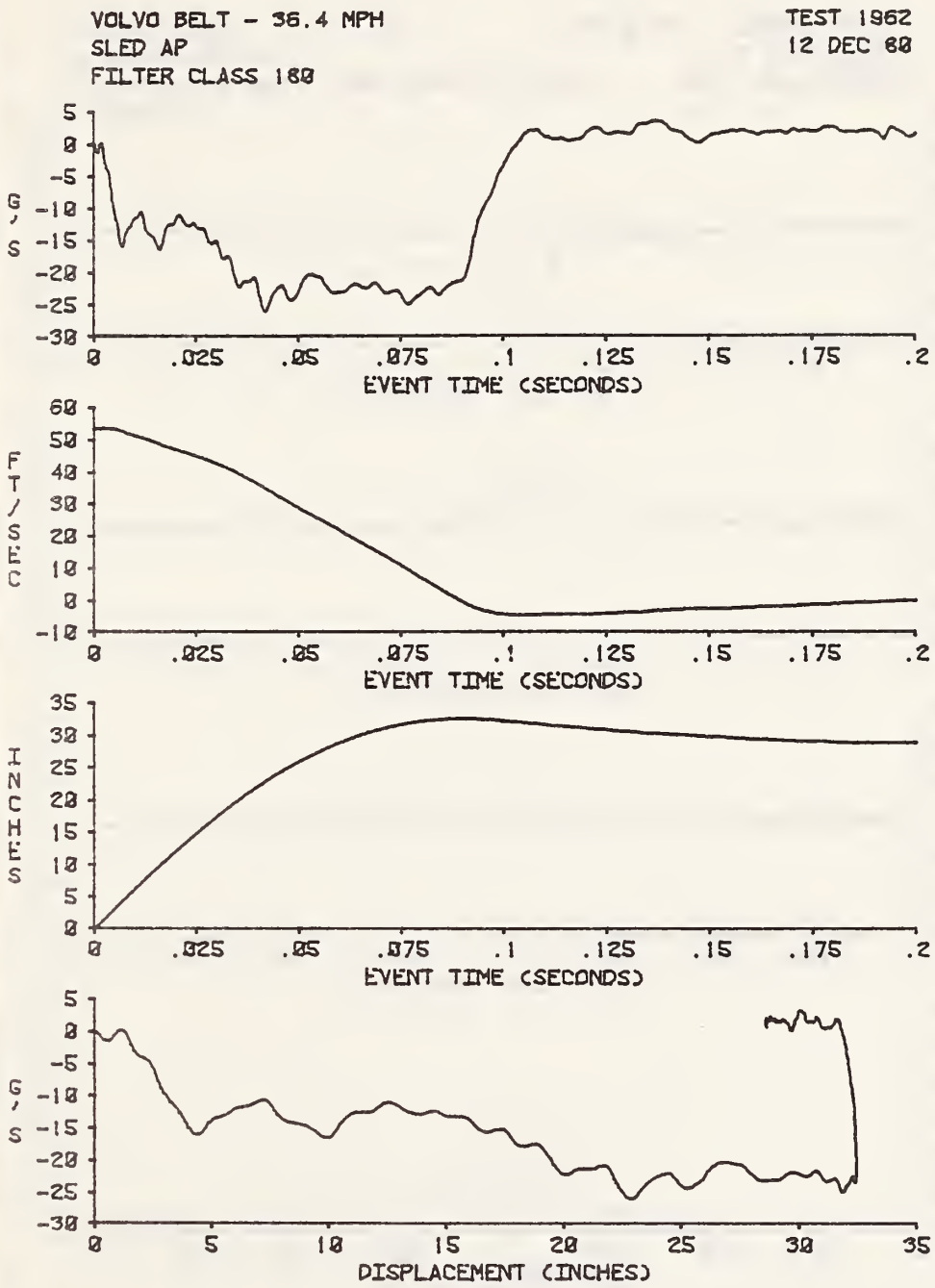
TEST 1962
12 DEC 80

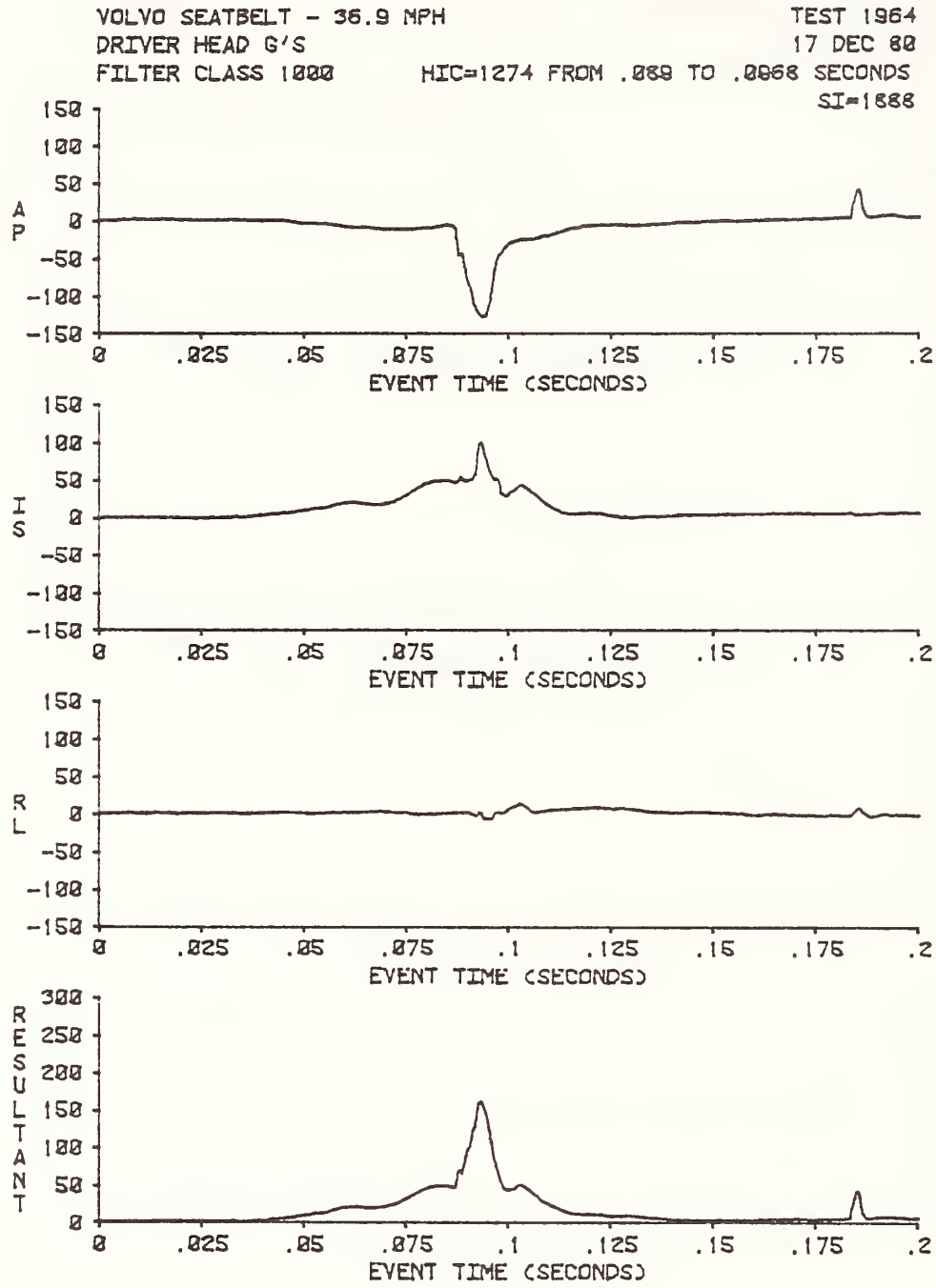


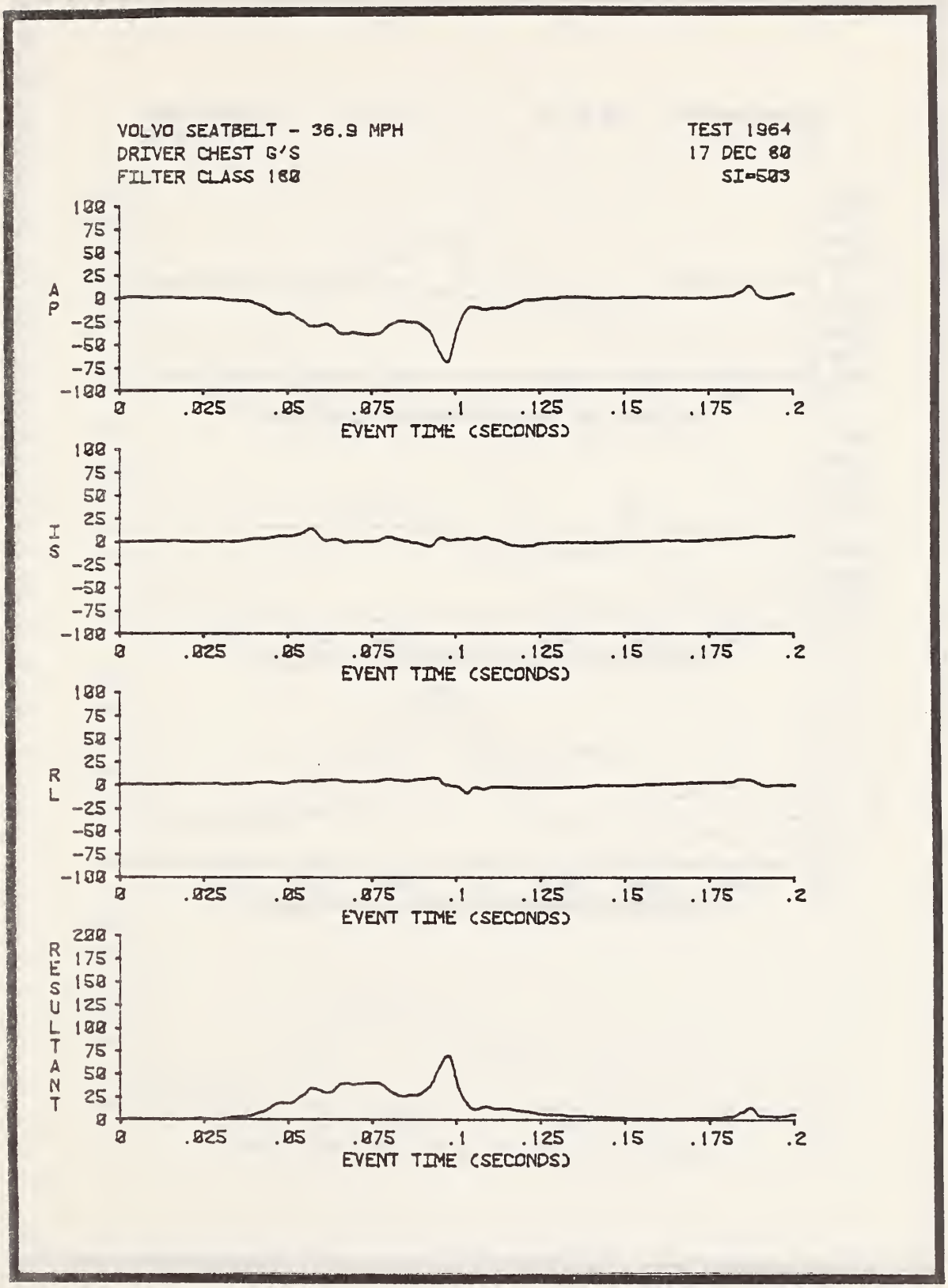
PASS. LEFT FEMUR FC 600 VS TIME (SEC)



PASS. RIGHT FEMUR FC 600 VS TIME (SEC)

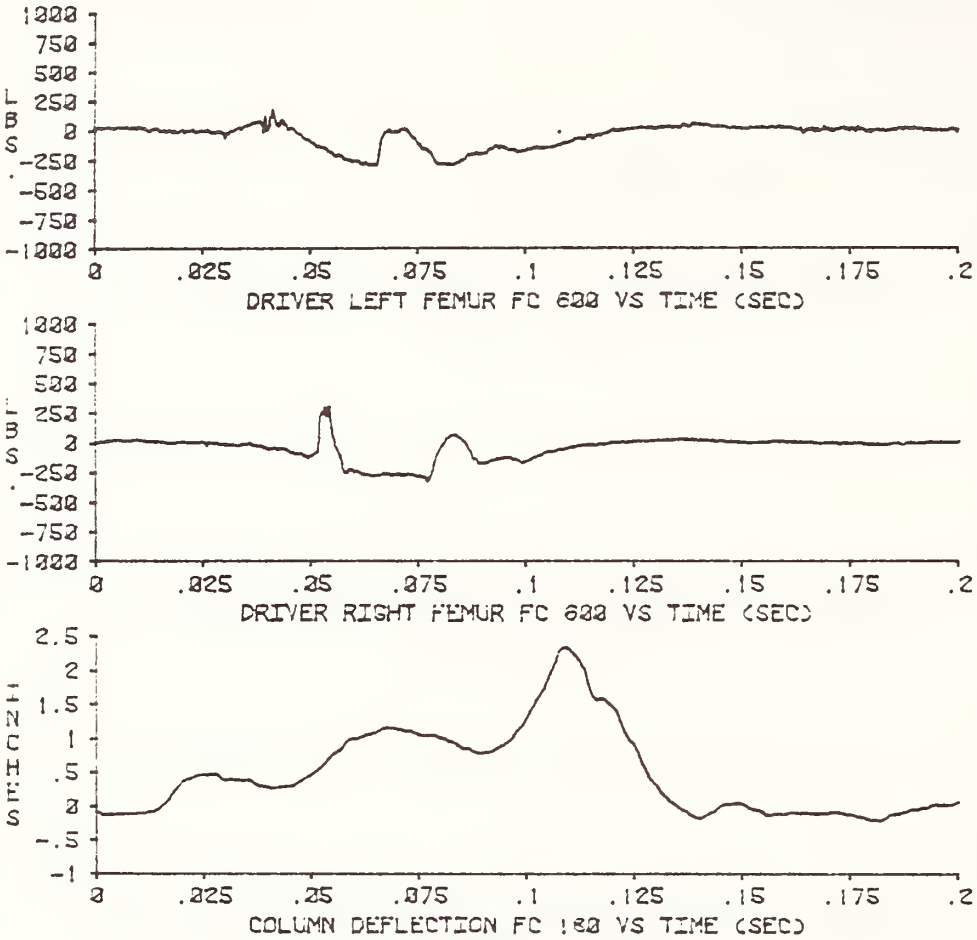

VOLVO BELT - 36.4 MPH
SLED AP
FILTER CLASS 180
TEST 1962
12 DEC 80
G'S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)
G'S
DISPLACEMENT (INCHES)


VOLVO SEATBELT - 36.9 MPH
TEST 1964
DRIVER HEAD G'S
17 DEC 80
FILTER CLASS 1000
HIC=1274 FROM .089 TO .0868 SECONDS
SI=1888
AP
IS
RL
RESULTANT
150
100
50
0
-50
-100
-150
300
250
200
150
100
50
0
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)


VOLVO SEATBELT - 36.9 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1964
17 DEC 80
SI=503
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
100
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

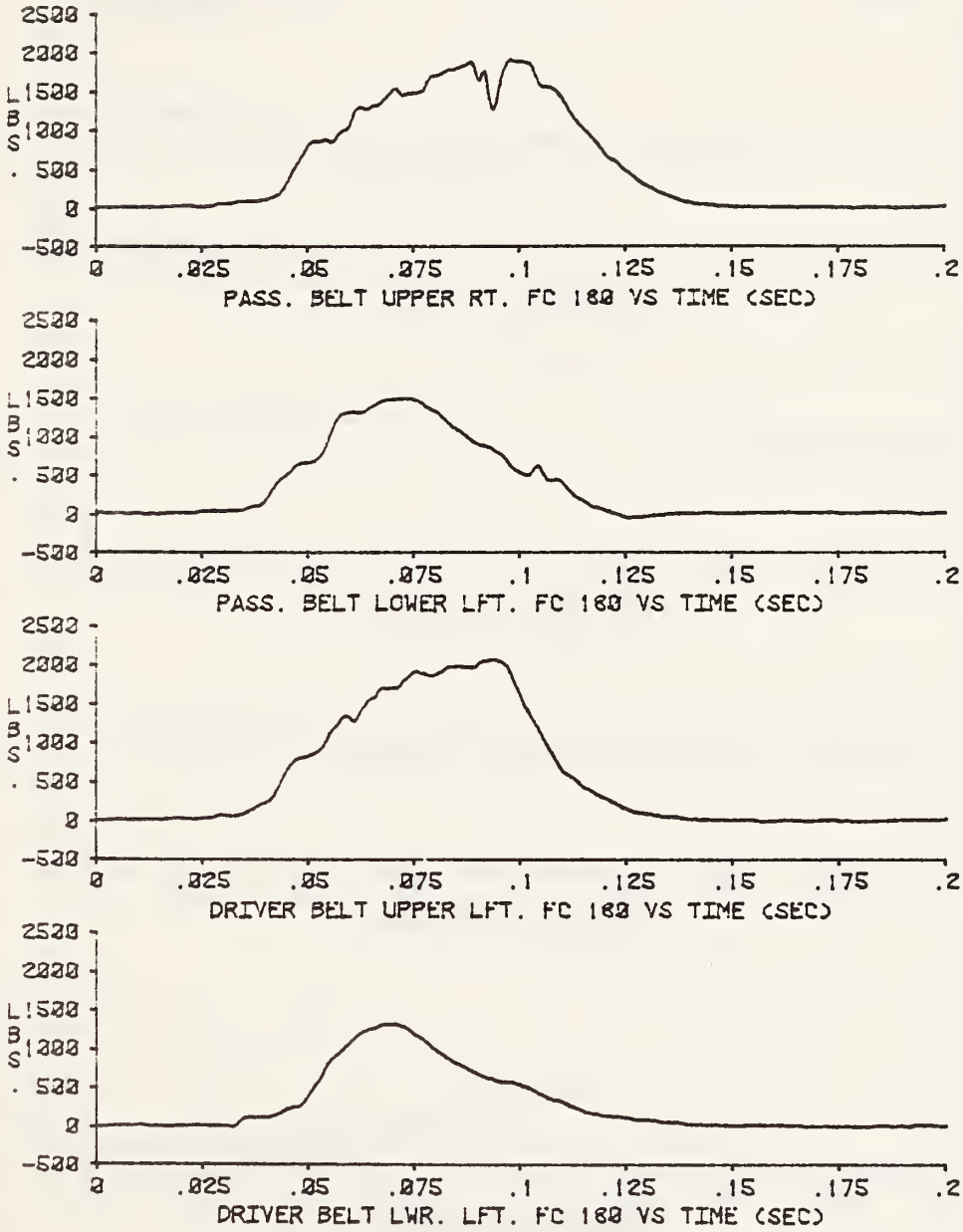
VOLVO SEATBELT - 36.9 MPH

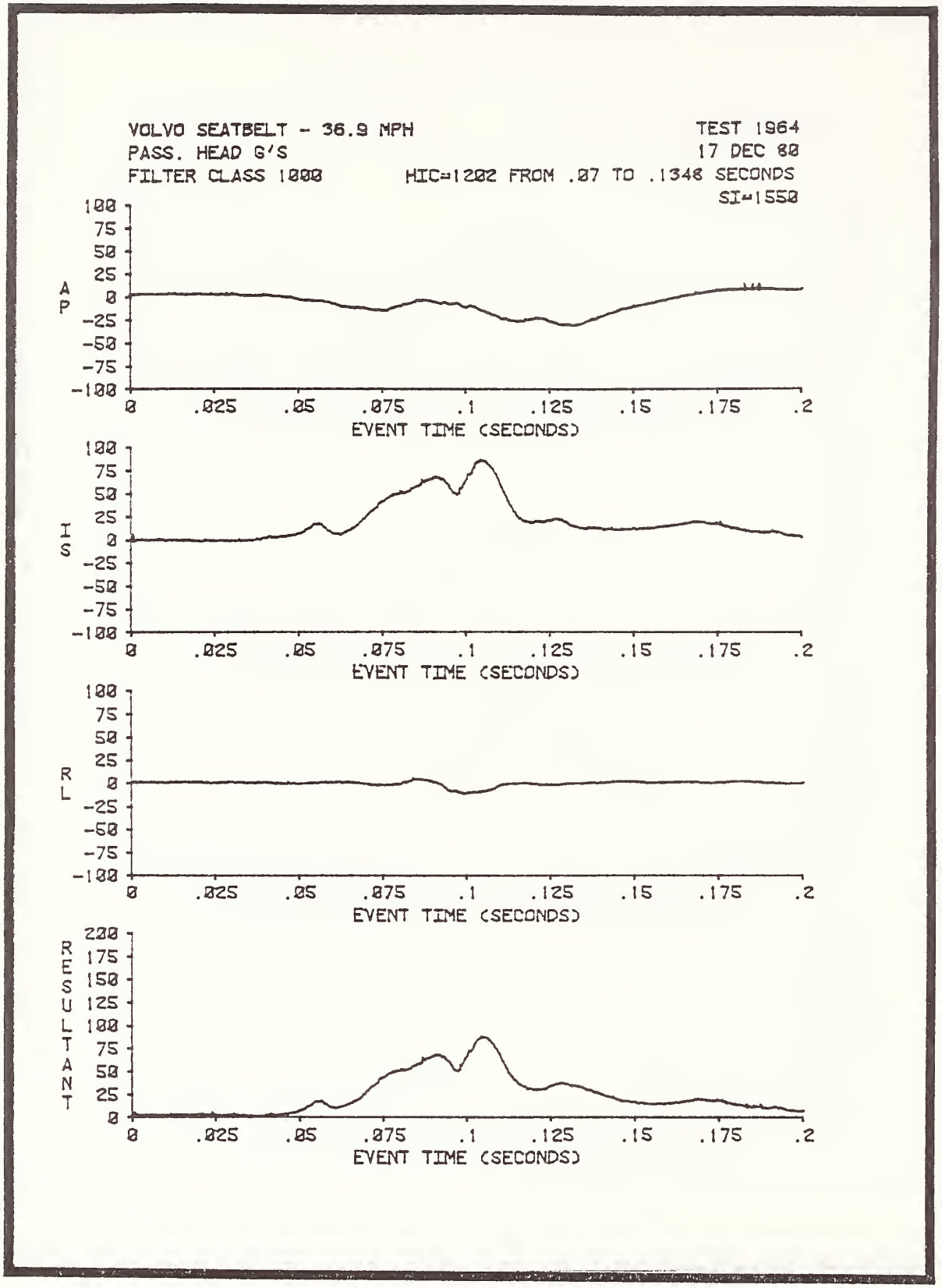
TEST 1964
17 DEC 80

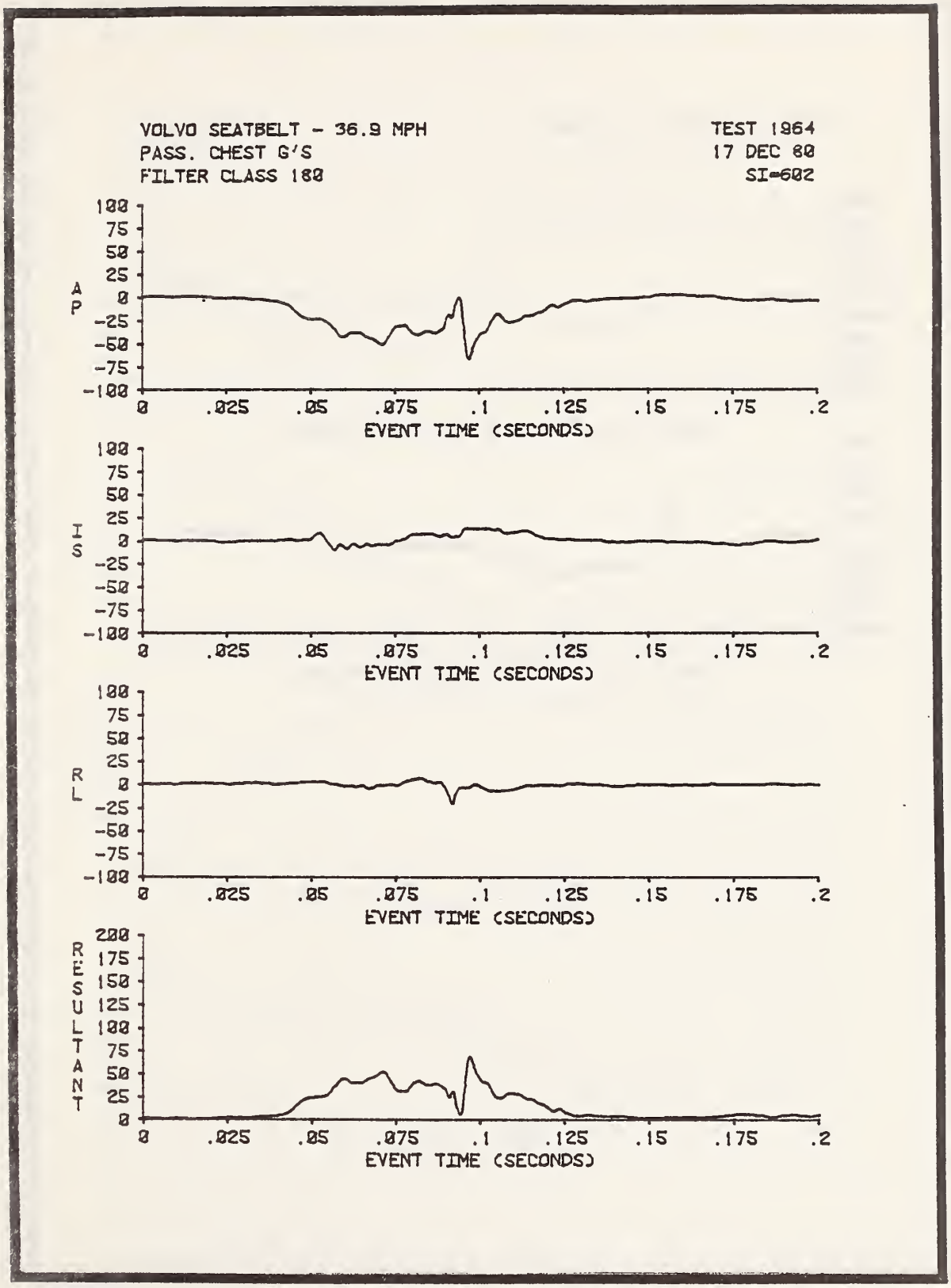


VOLVO SEATBELT - 36.9 MPH

TEST 1964
17 DEC 80

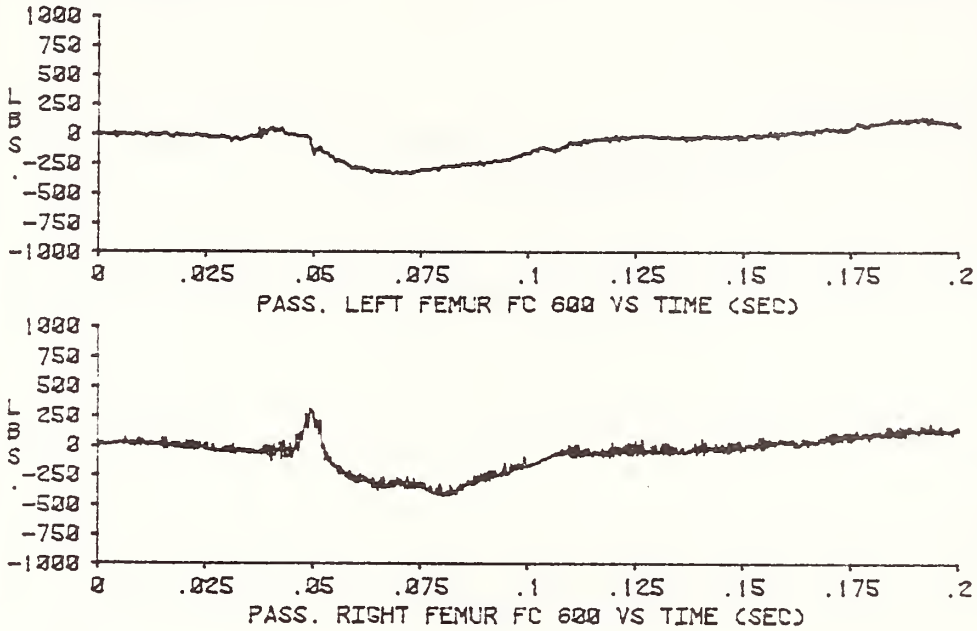


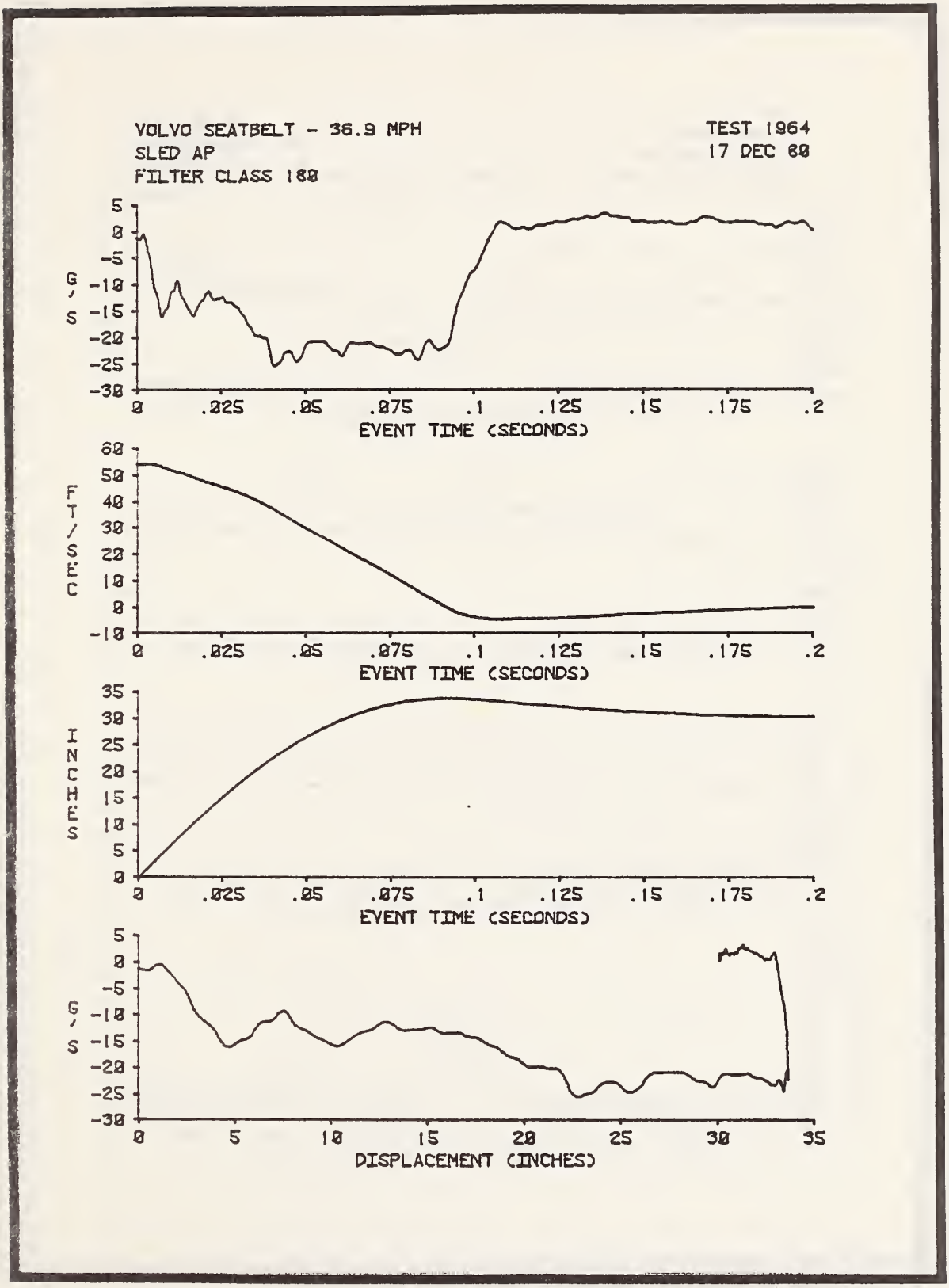

VOLVO SEATBELT - 36.9 MPH
TEST 1964
PASS. HEAD G'S
17 DEC 80
FILTER CLASS 1000
HIC=1202 FROM .07 TO .1348 SECONDS
SI=1550
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

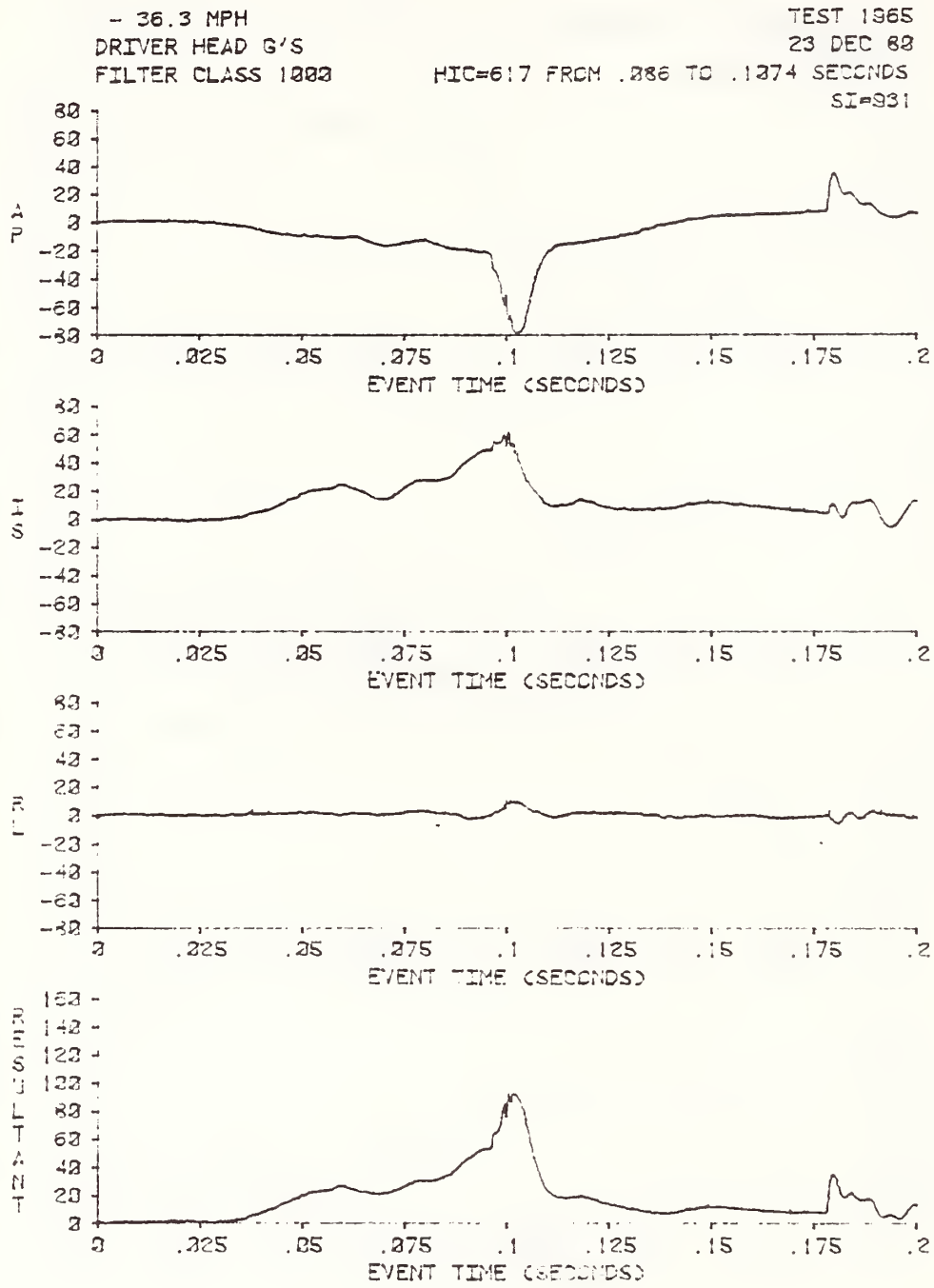

VOLVO SEATBELT - 36.9 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1964
17 DEC 80
SI=602
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
-100
200
175
150
125
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

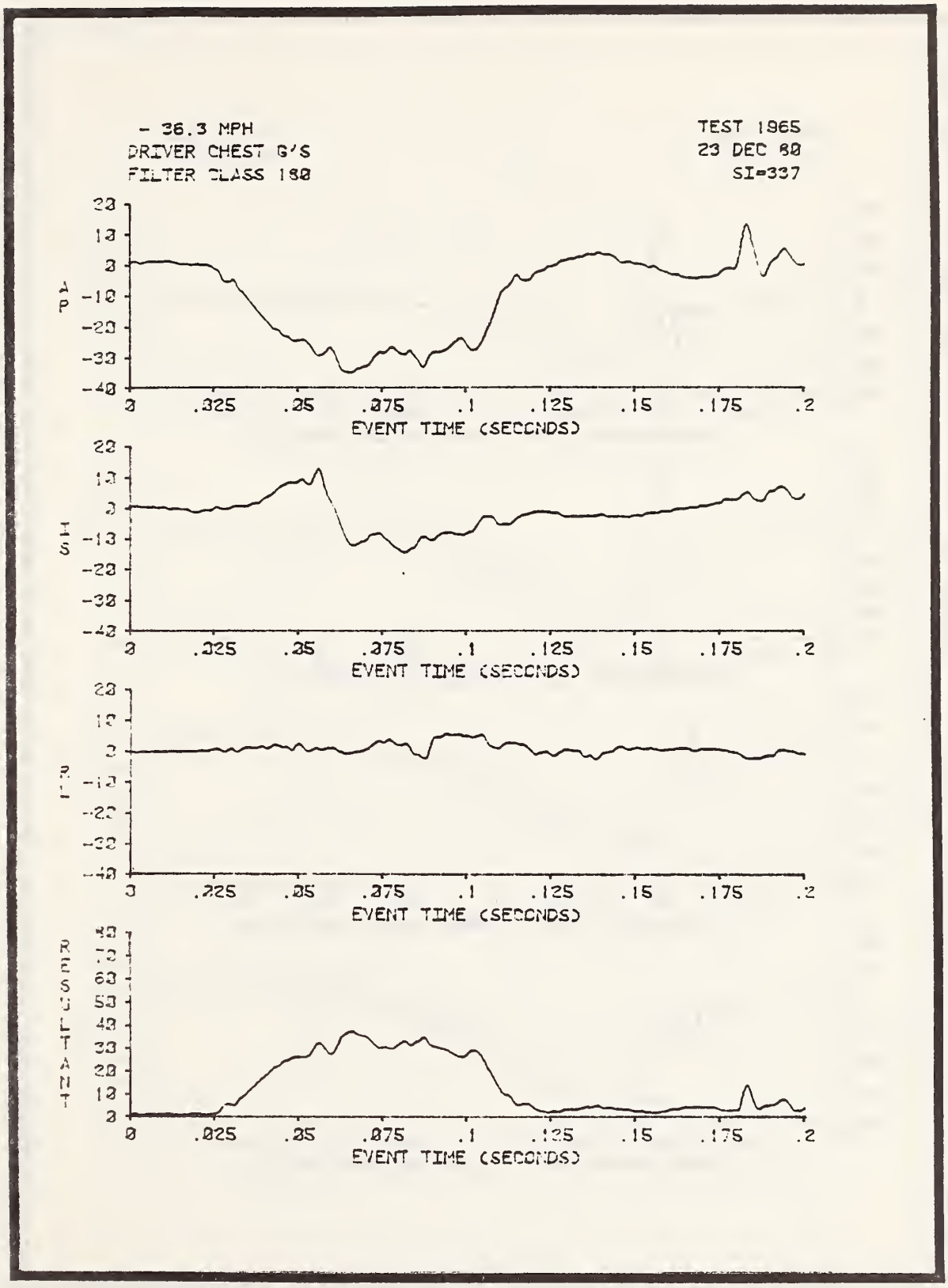
VOLVO SEATBELT - 36.9 MPH

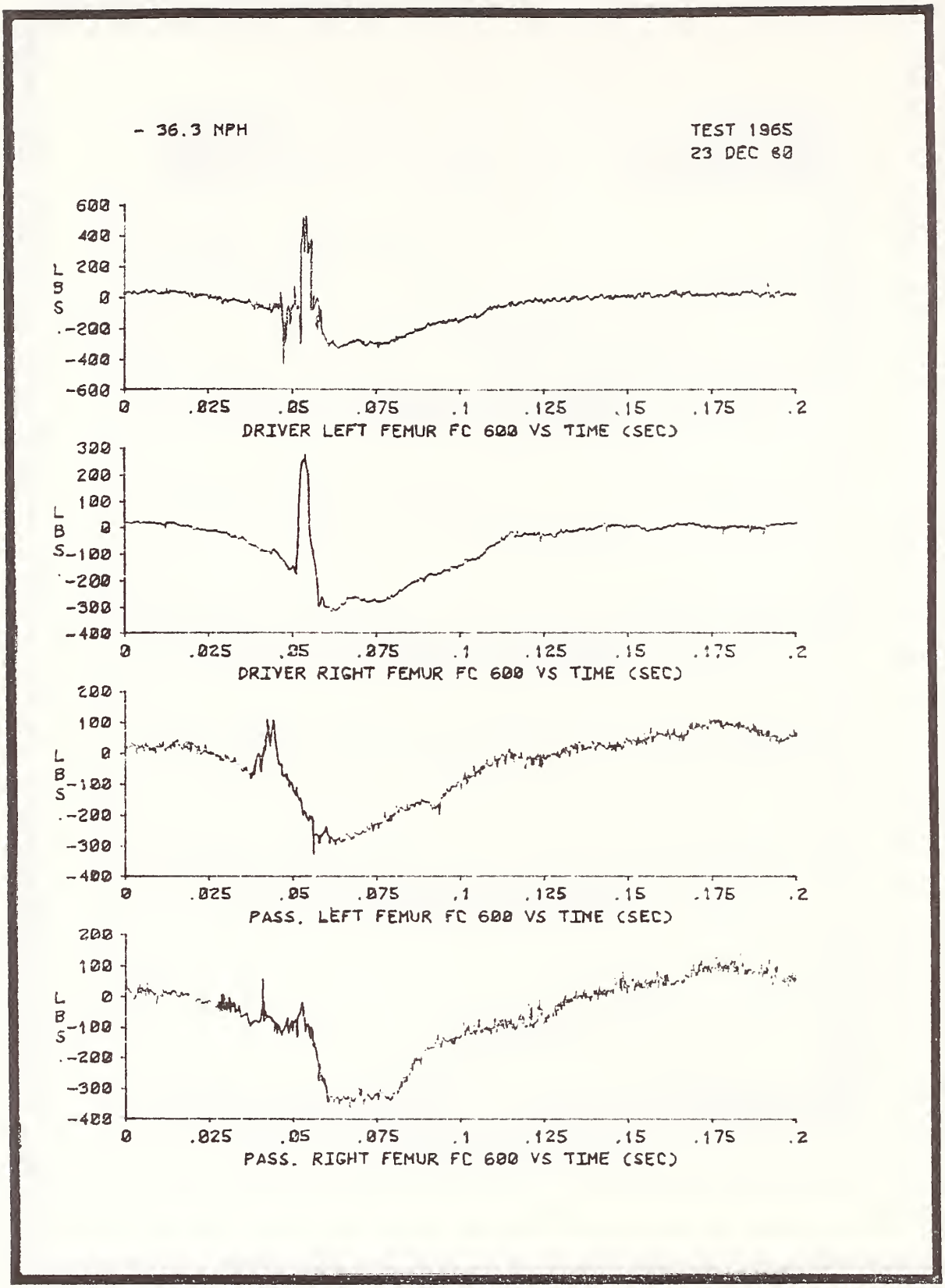
TEST 1964
17 DEC 80

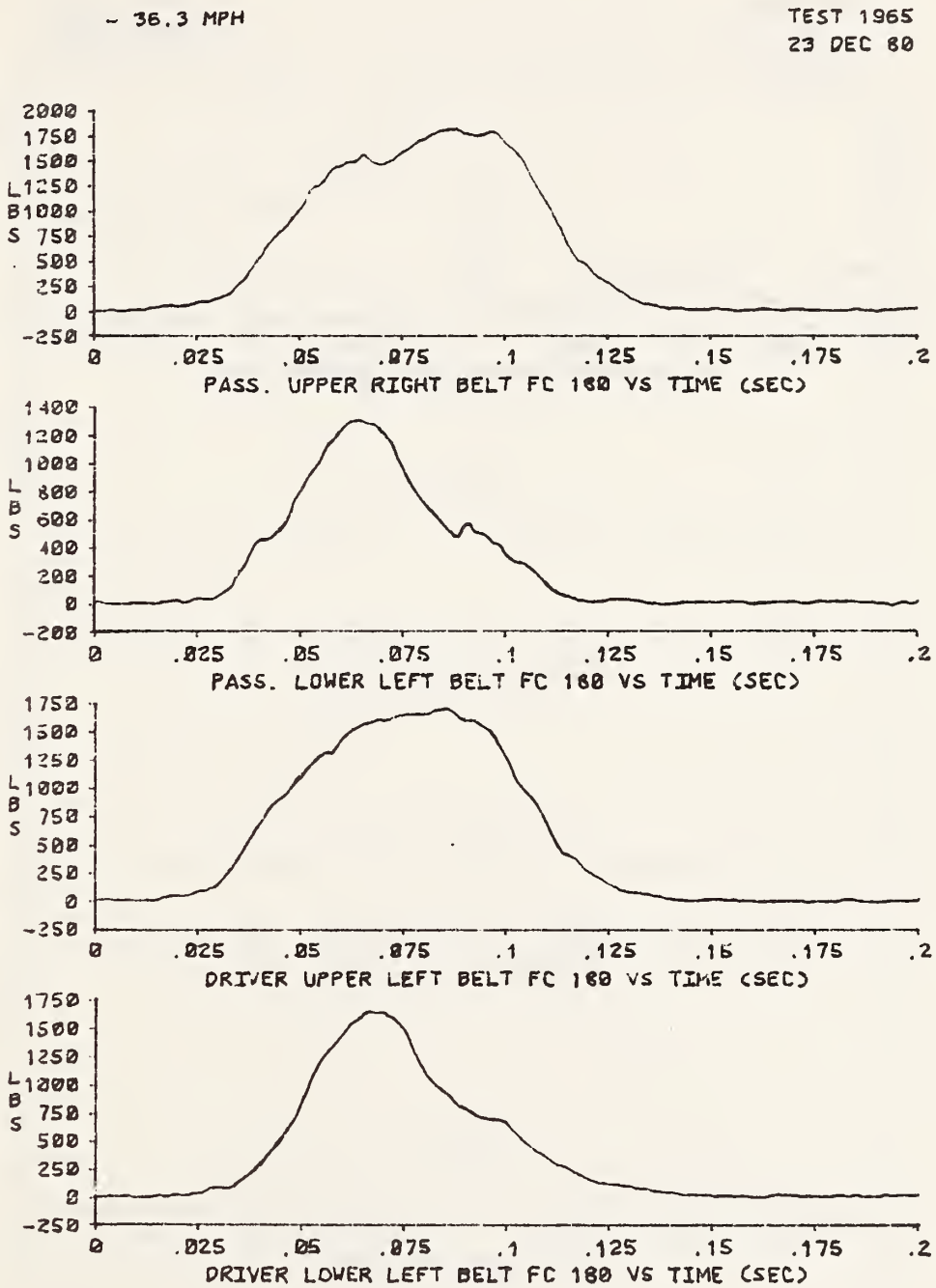


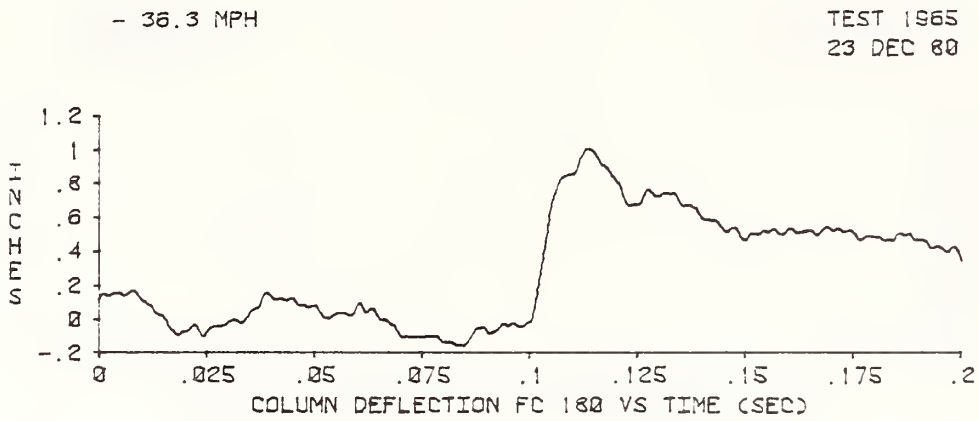

VOLVO SEATBELT - 36.9 MPH
SLED AP
FILTER CLASS 180
TEST 1964
17 DEC 80
G'S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)
G'S
DISPLACEMENT (INCHES)

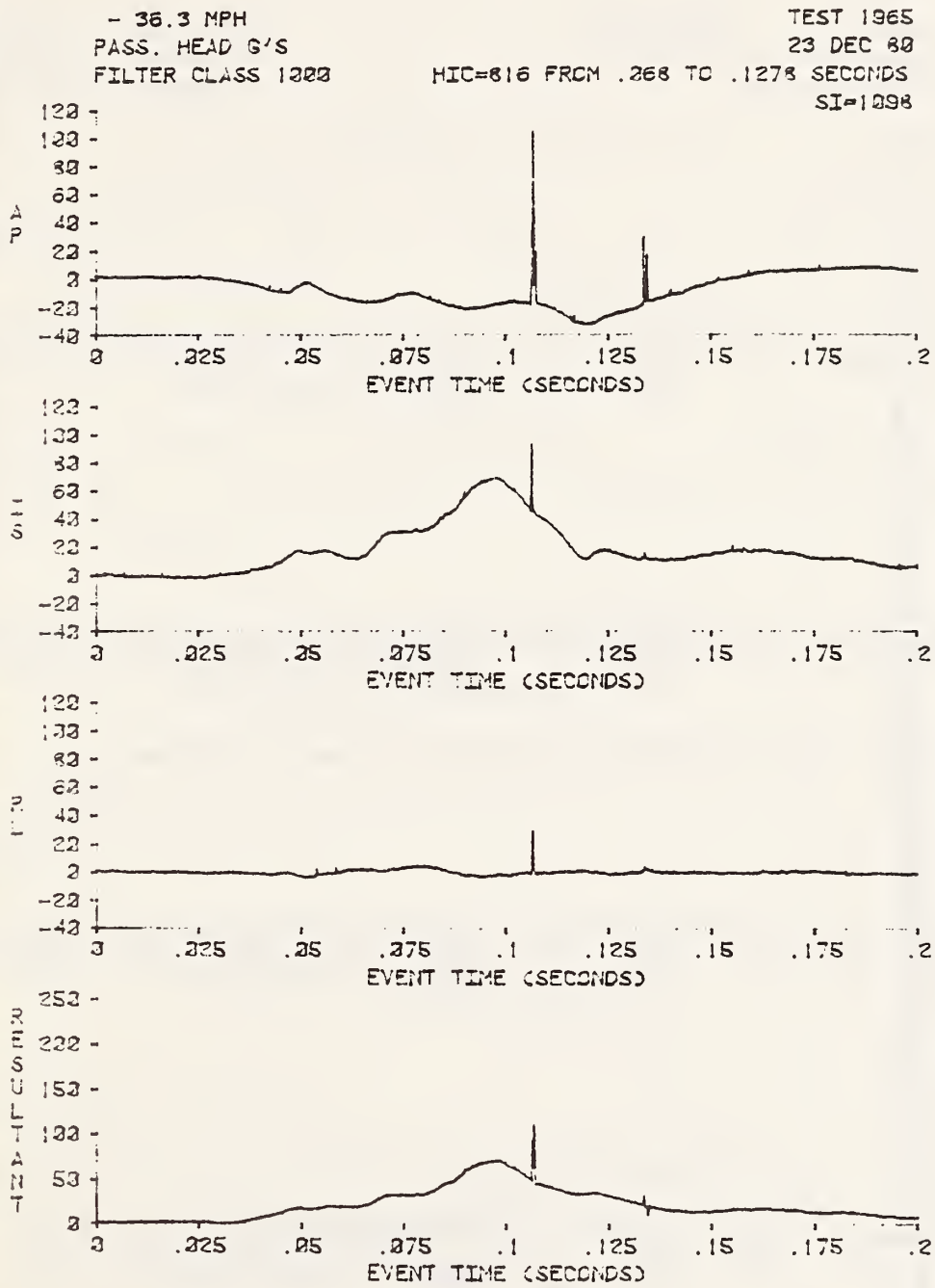

- 36.3 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
TEST 1965
23 DEC 80
HIC=617 FROM .086 TO .1374 SECONDS
SI=931
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)

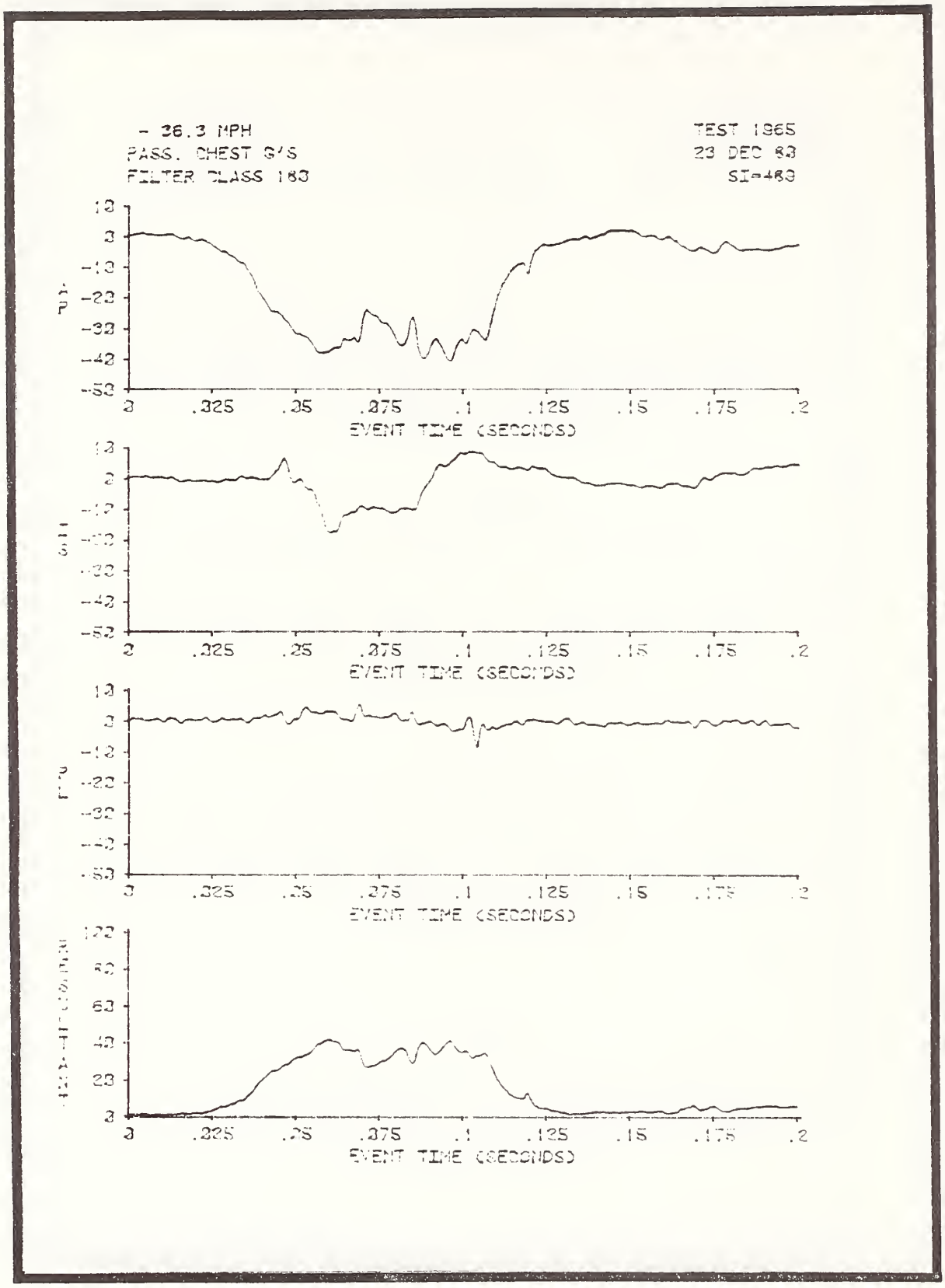

- 36.3 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1965
23 DEC 80
SI=337
AP
HS
RESULTANT
EVENT TIME (SECONDS)

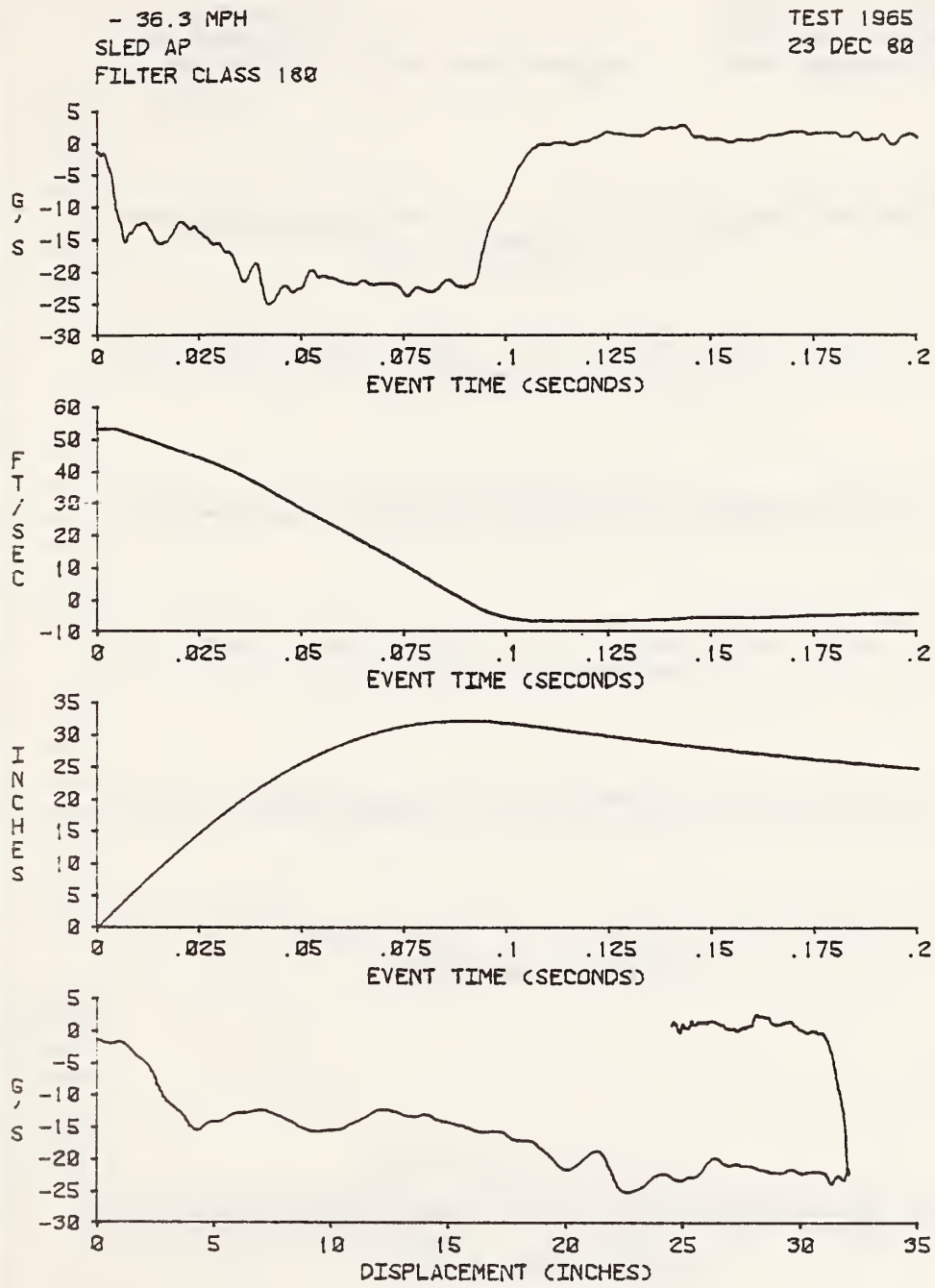

- 36.3 MPH
TEST 1965
23 DEC 80
LBS
600
400
200
0
-200
-400
-600
0
.025
.05
.075
.1
.125
.15
.175
.2
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)
300
200
100
0
-100
-200
-300
-400
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)
PASS. LEFT FEMUR FC 600 VS TIME (SEC)
PASS. RIGHT FEMUR FC 600 VS TIME (SEC)

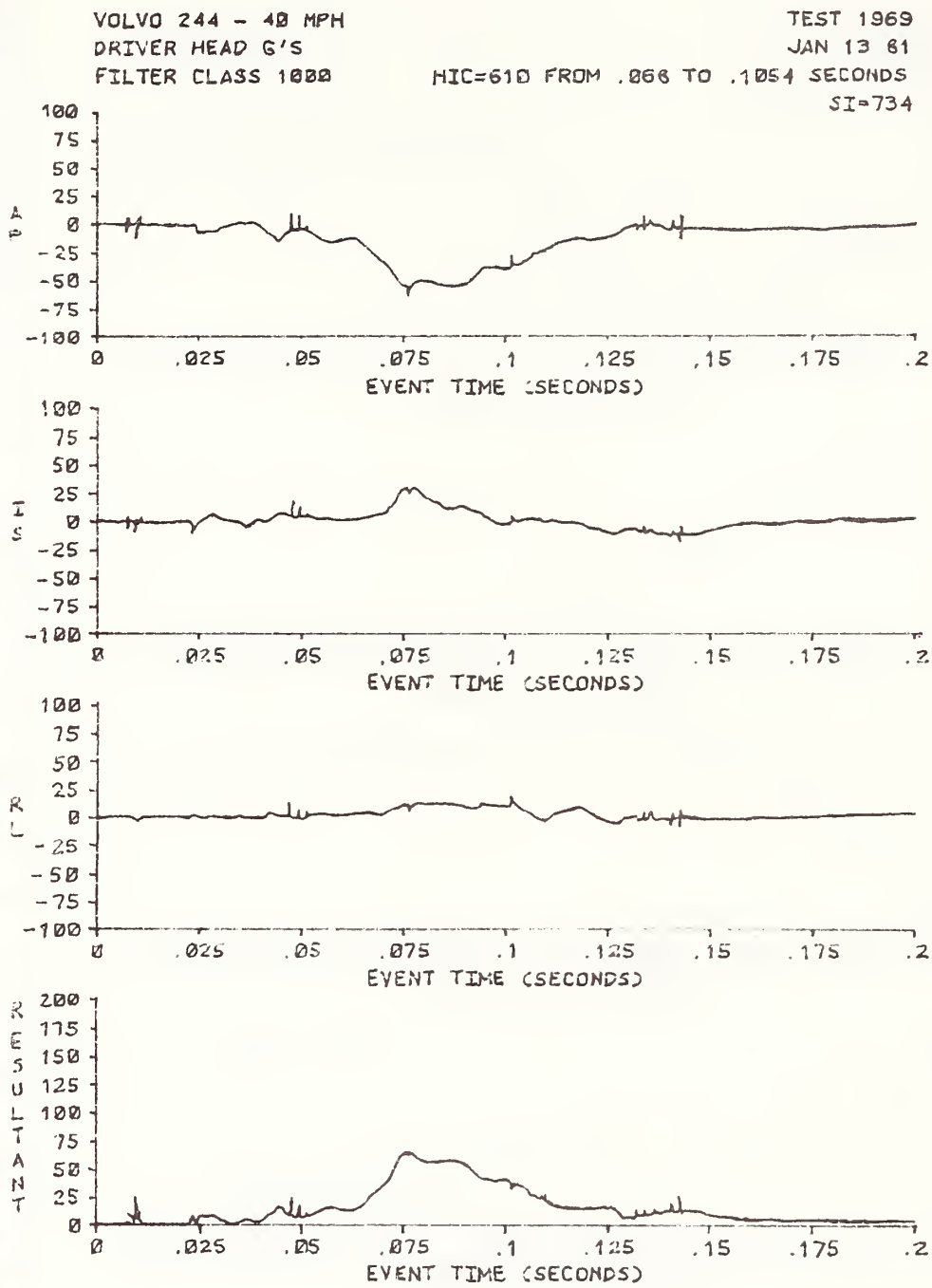

~ 36.3 MPH
TEST 1965
23 DEC 80
LBS
PASS. UPPER RIGHT BELT FC 160 VS TIME (SEC)
PASS. LOWER LEFT BELT FC 160 VS TIME (SEC)
DRIVER UPPER LEFT BELT FC 160 VS TIME (SEC)
DRIVER LOWER LEFT BELT FC 160 VS TIME (SEC)

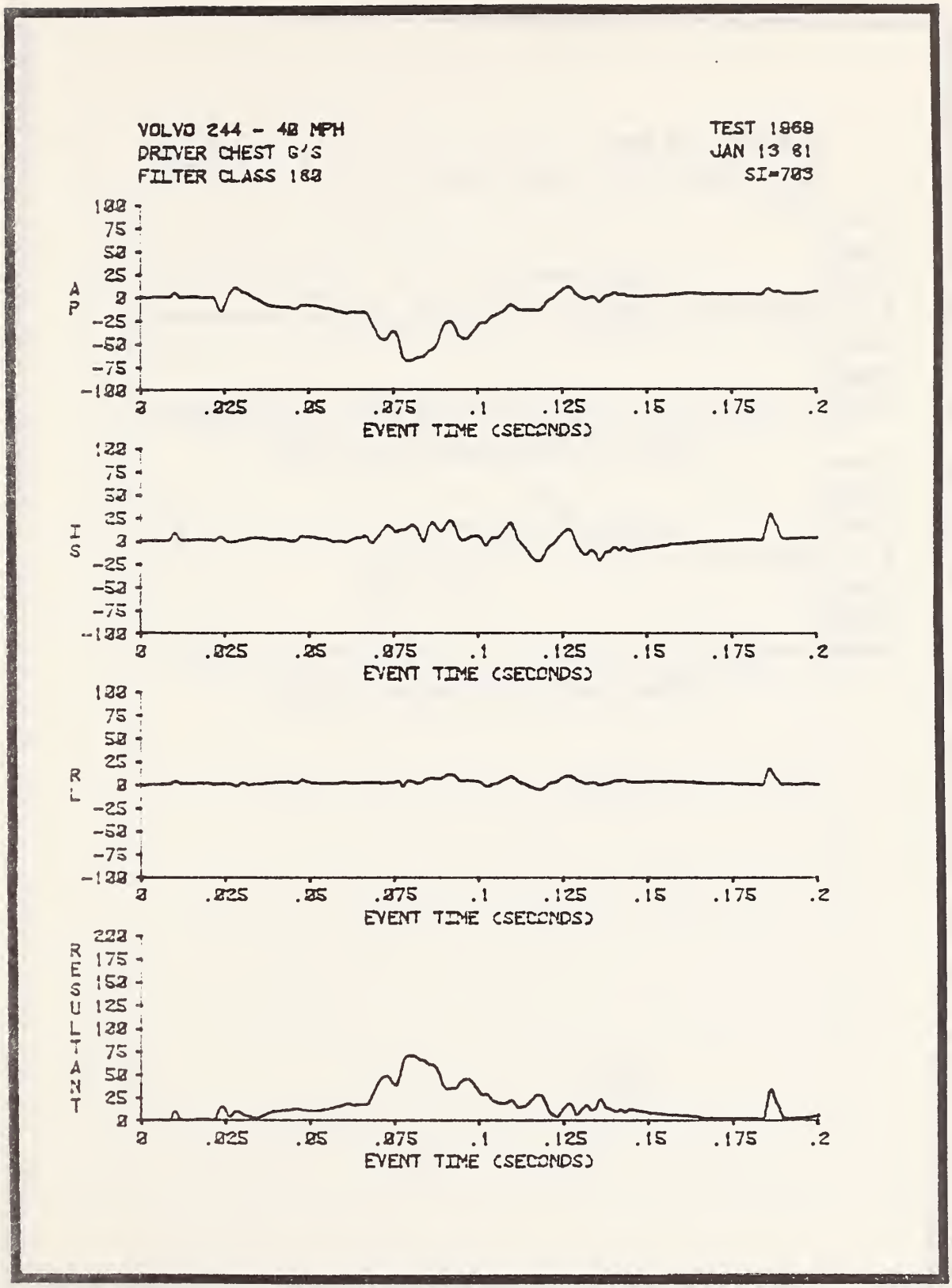

- 36.3 MPH
TEST 1965
23 DEC 80
INCHES
1.2
1
.8
.6
.4
.2
0
-.2
0
.025
.05
.075
.1
.125
.15
.175
.2
COLUMN DEFLECTION FC 180 VS TIME (SEC)

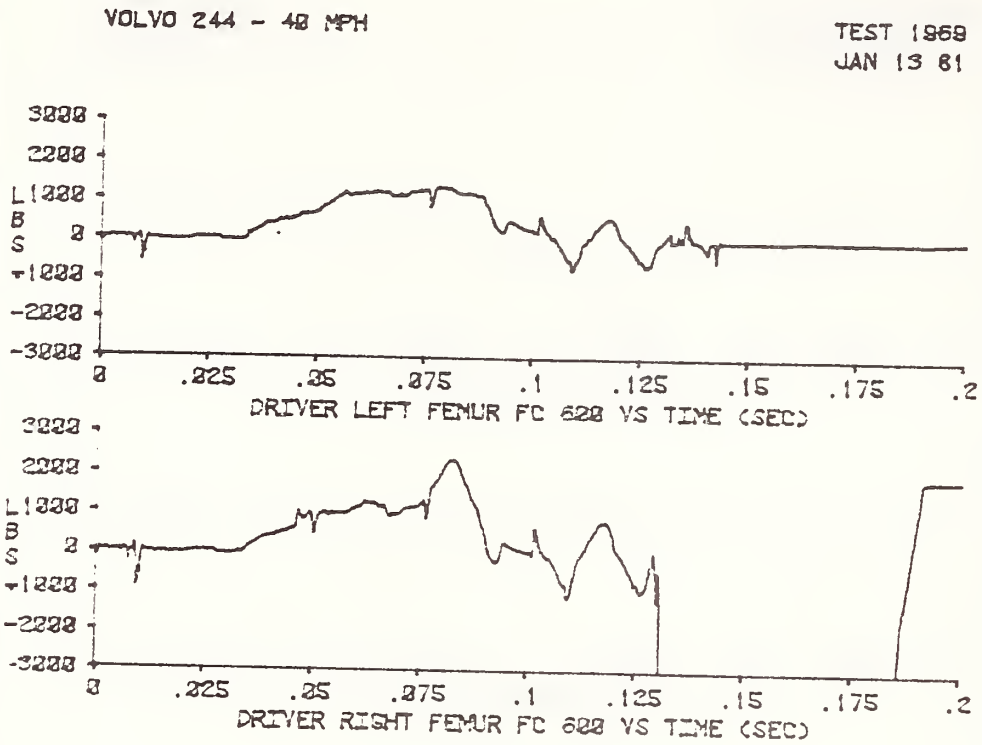

- 36.3 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=616 FROM .268 TO .1278 SECONDS
SI=1098
TEST 1965
23 DEC 80
AP
LTS
RTS
RESULTANT
EVENT TIME (SECONDS)

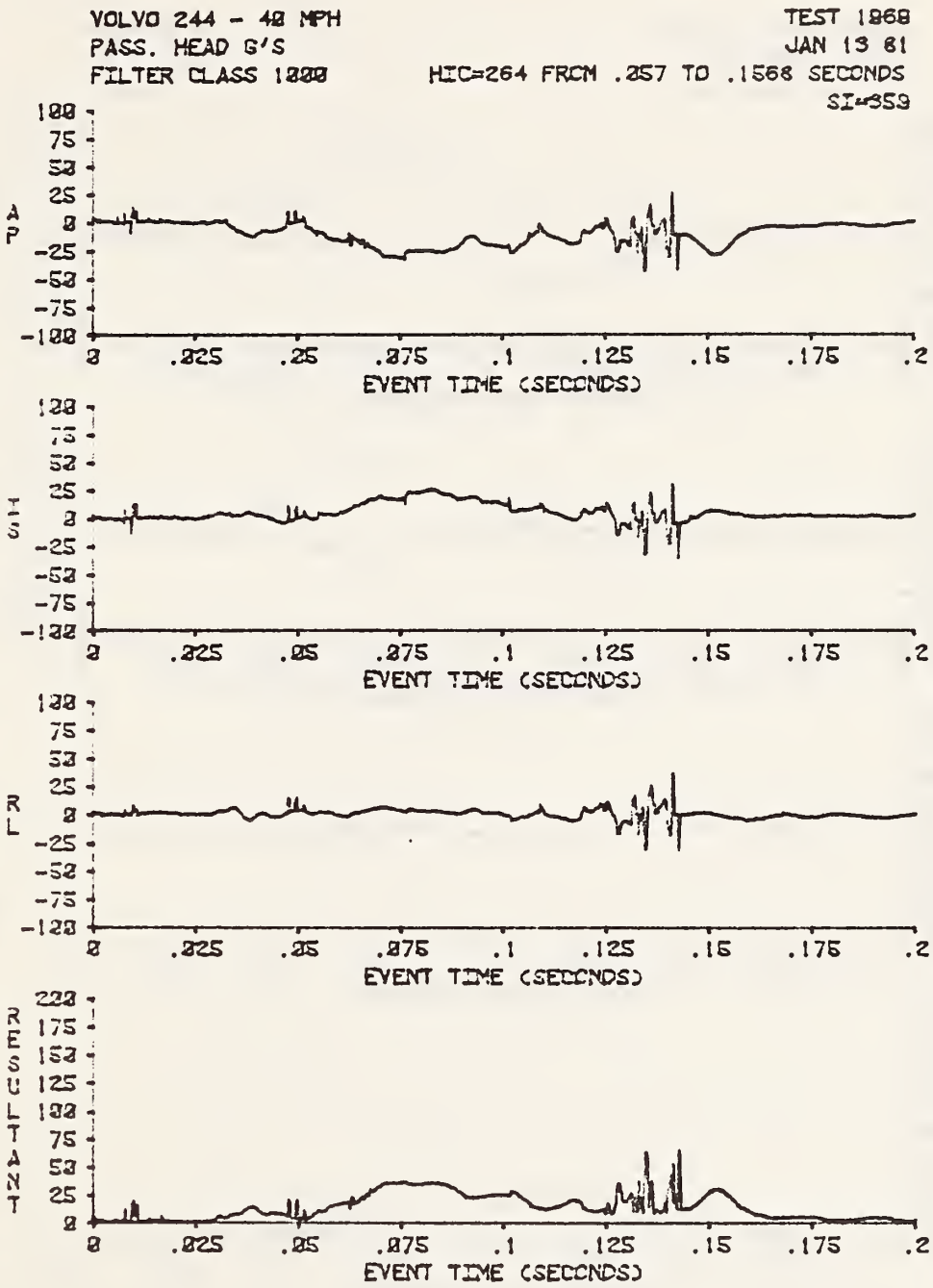

- 36.3 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1965
23 DEC 83
SI=480
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)

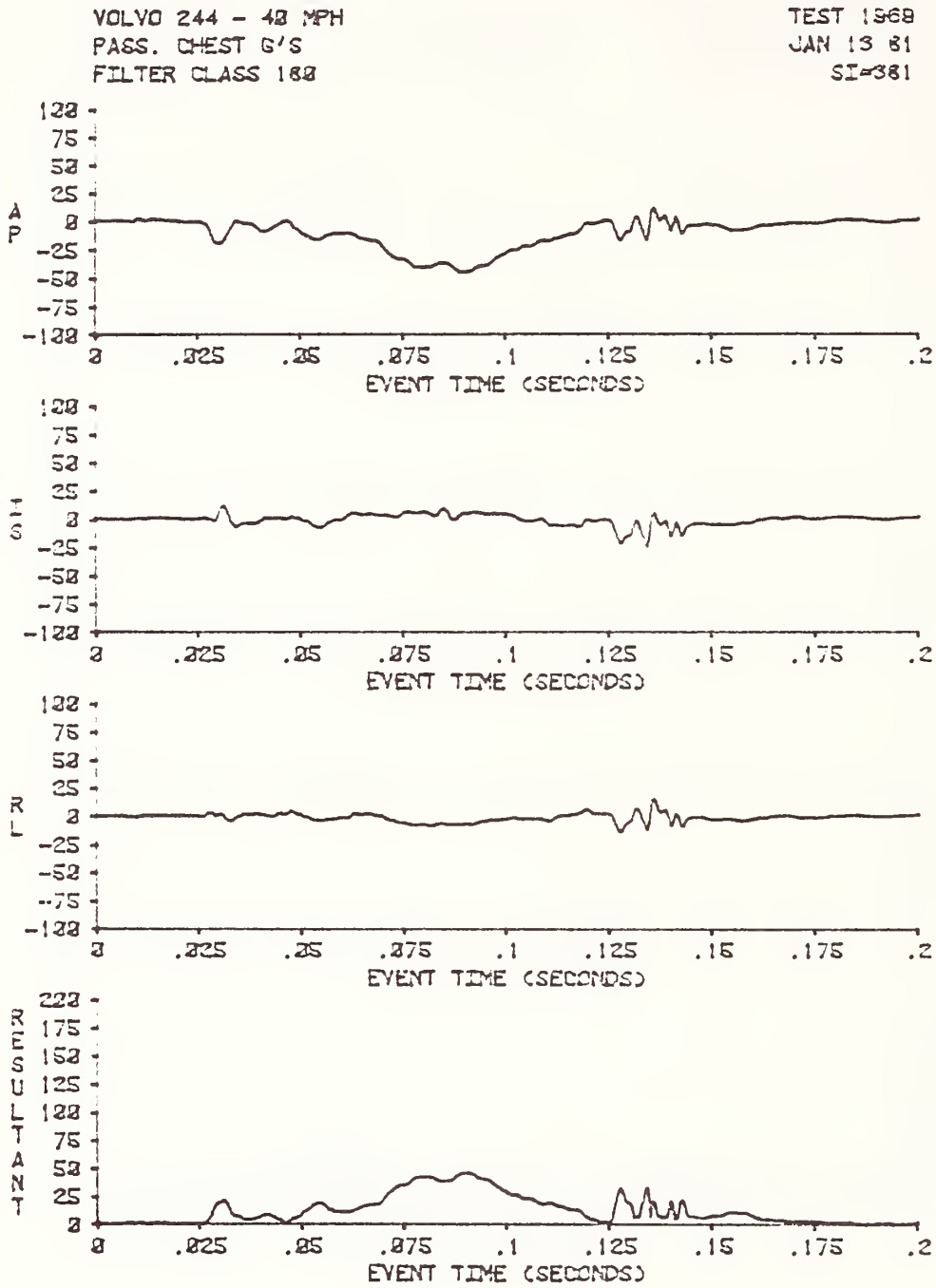

- 36.3 MPH
SLED AP
FILTER CLASS 180
TEST 1965
23 DEC 80
G'S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)
G'S
DISPLACEMENT (INCHES)


VOLVO 244 - 40 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
TEST 1969
JAN 13 81
HIC=610 FROM .066 TO .1054 SECONDS
SI=734
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)


VOLVO 244 - 40 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1868
JAN 13 81
SI=703
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO 244 - 40 MPH
TEST 1868
JAN 13 81
3000
2000
LBS 1000
0
-1000
-2000
-3000
0
.025
.05
.075
.1
.125
.15
.175
.2
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)
3000
2000
LBS 1000
0
-1000
-2000
-3000
0
.025
.05
.075
.1
.125
.15
.175
.2
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)

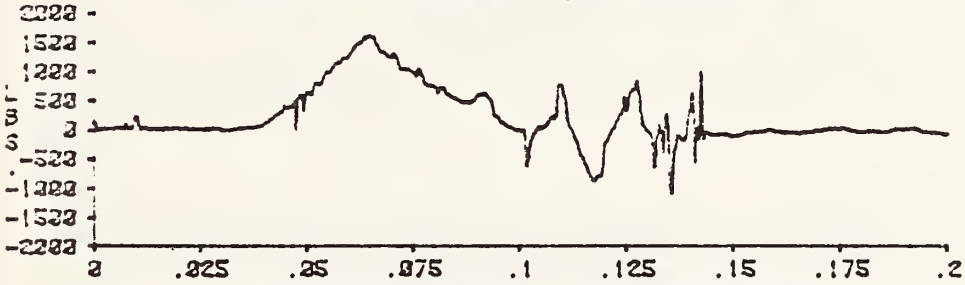

VOLVO 244 - 40 MPH
PASS. HEAD G'S
FILTER CLASS 1000
TEST 1868
JAN 13 81
HIC=264 FROM .257 TO .1568 SECONDS
SI=359
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO 244 - 40 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1968
JAN 13 81
SI=381
AP
LTS
RL
RESULTANT
EVENT TIME (SECONDS)

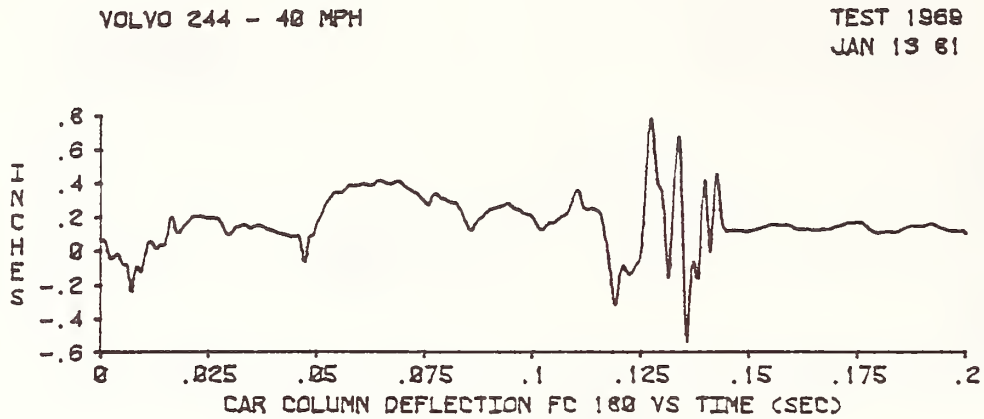
VOLVO 244 - 40 MPH

TEST 1968
JAN 13 81

PASS. LEFT FEMUR FC 600 VS TIME (SEC)

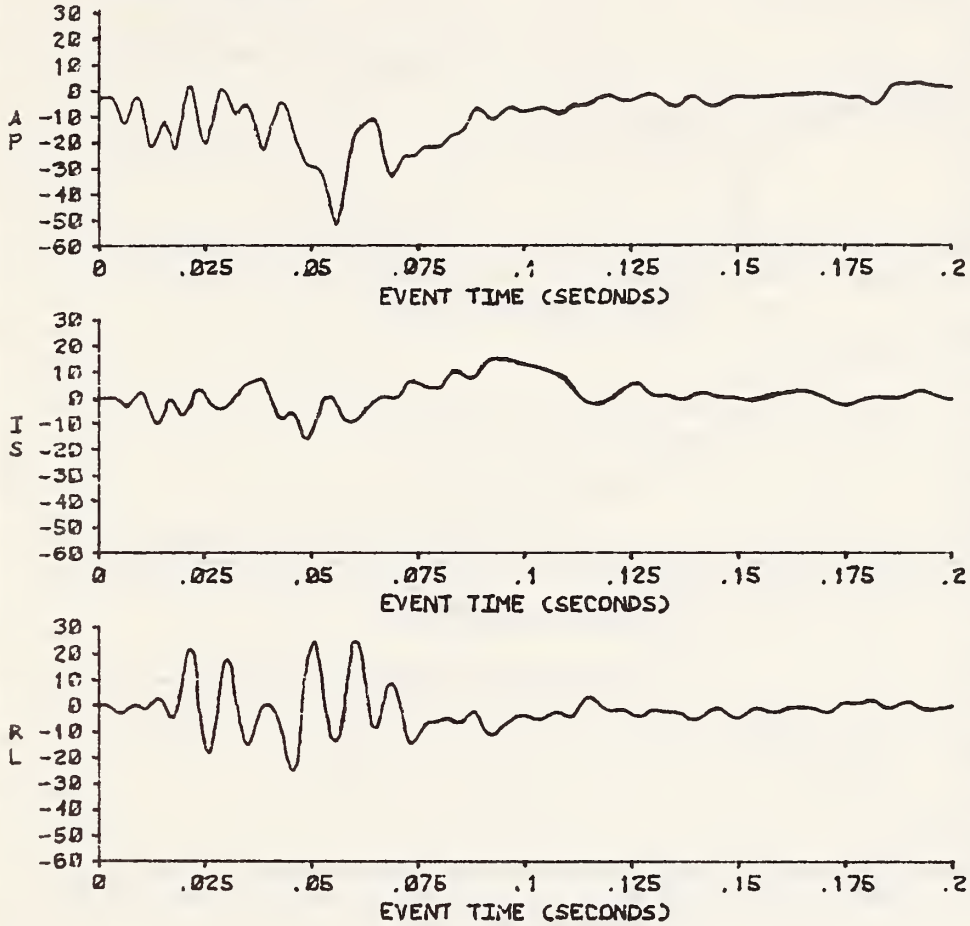


PASS. RIGHT FEMUR FC 600 VS TIME (SEC)


VOLVO 244 - 40 MPH
TEST 1969
JAN 13 81
INCHES
.8
.6
.4
.2
0
-.2
-.4
-.6
0
.025
.05
.075
.1
.125
.15
.175
.2
CAR COLUMN DEFLECTION FC 180 VS TIME (SEC)

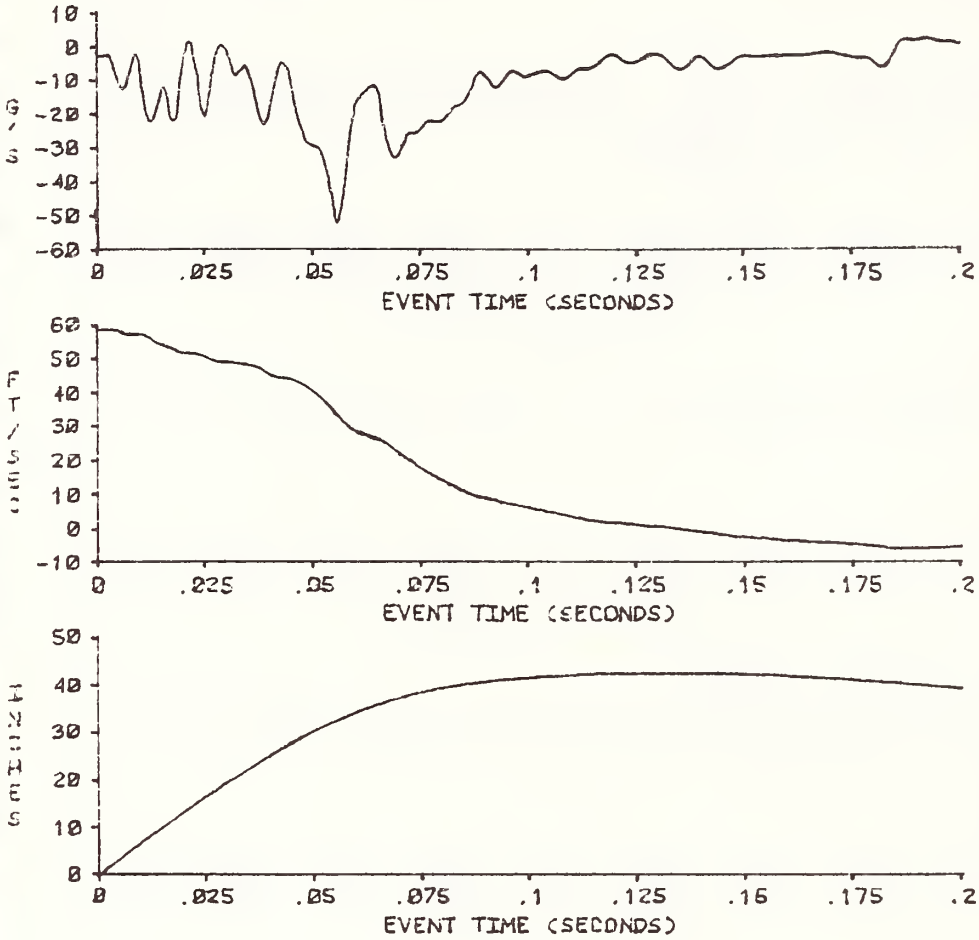
VOLVO 244 - 40 MPH
CAR RIGHT 'A' PILLAR G'S
FILTER CLASS 60

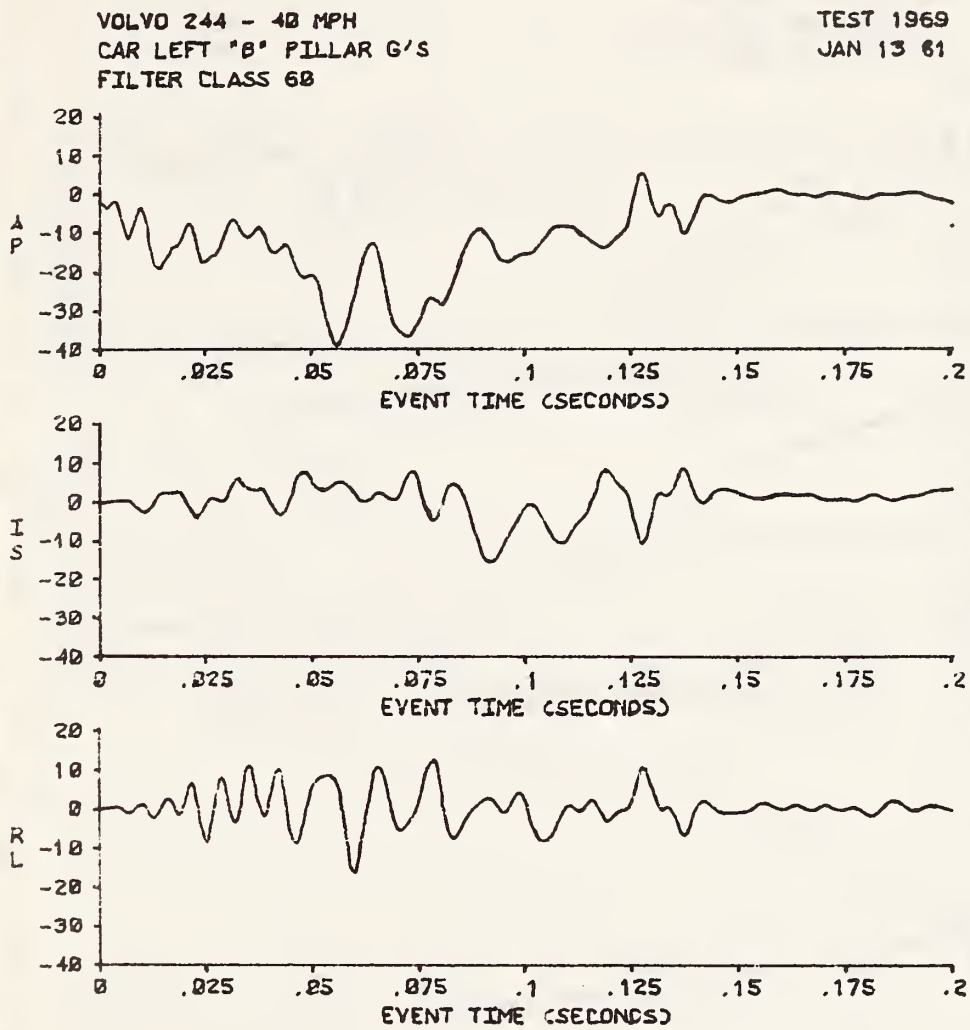
TEST 1969
JAN 13 81

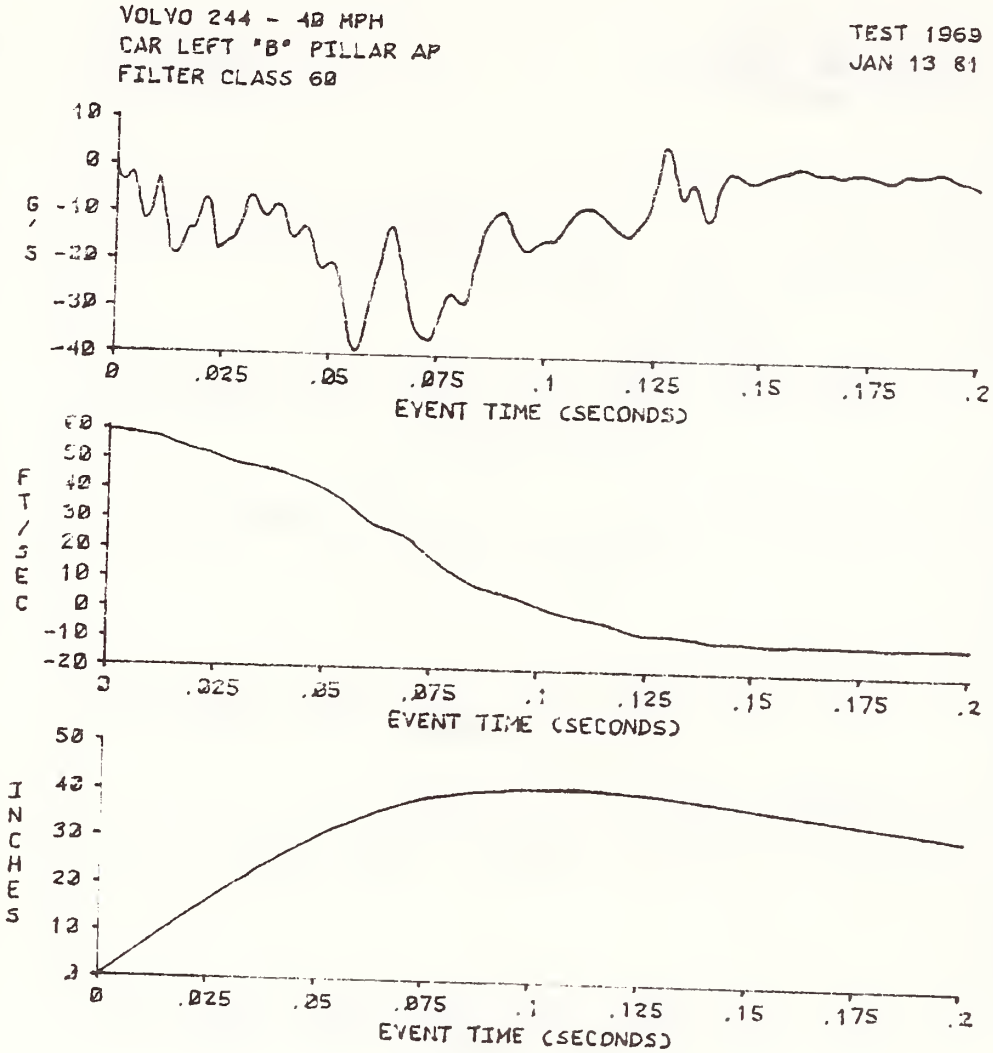


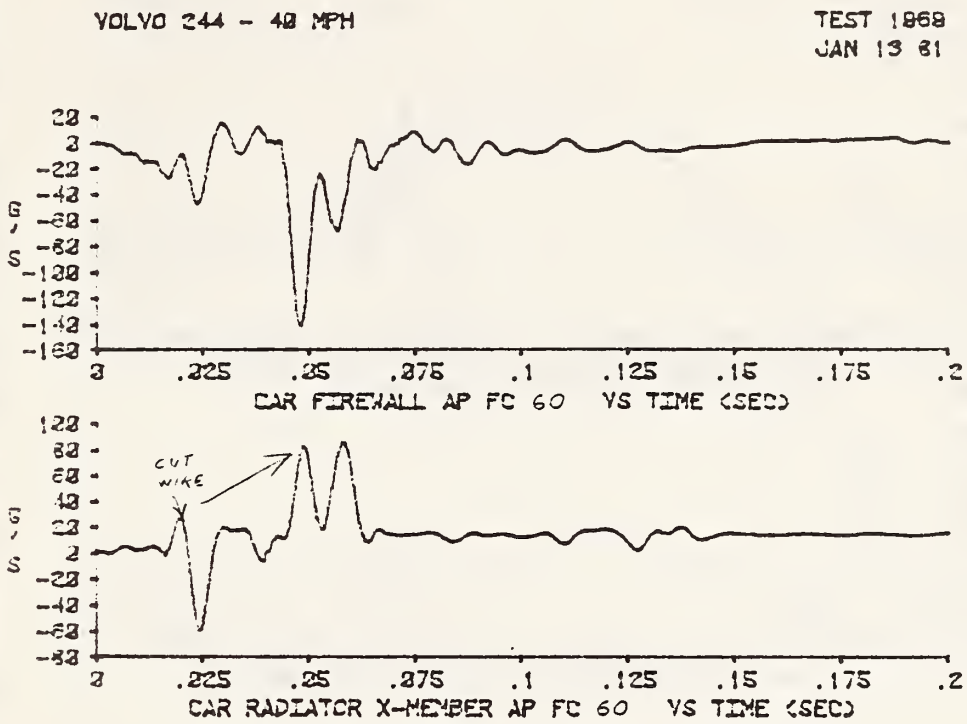
VOLVO 244 - 40 MPH
CAR RIGHT 'A' PILLAR AP
FILTER CLASS 60

TEST 1969
JAN 13 81



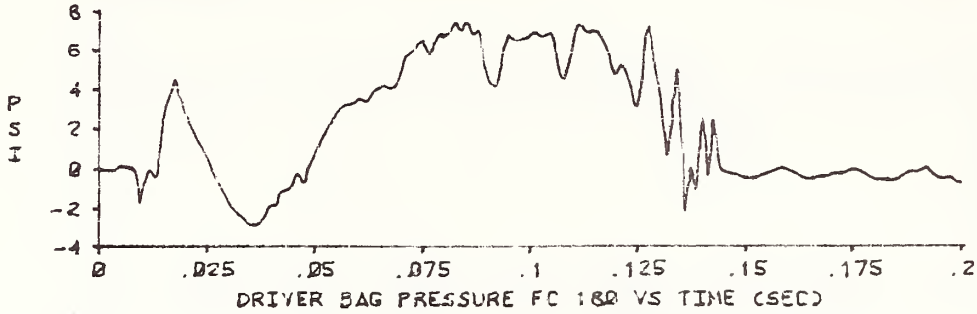

VOLVO 244 - 40 MPH
CAR LEFT "B" PILLAR G'S
FILTER CLASS 60
TEST 1969
JAN 13 61
AP
IS
RL
20
10
0
-10
-20
-30
-40
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)


VOLVO 244 - 40 MPH
CAR LEFT "B" PILLAR AP
FILTER CLASS 60
TEST 1969
JAN 13 81
G/S
EVENT TIME (SECONDS)
FT/SEC
EVENT TIME (SECONDS)
INCHES
EVENT TIME (SECONDS)

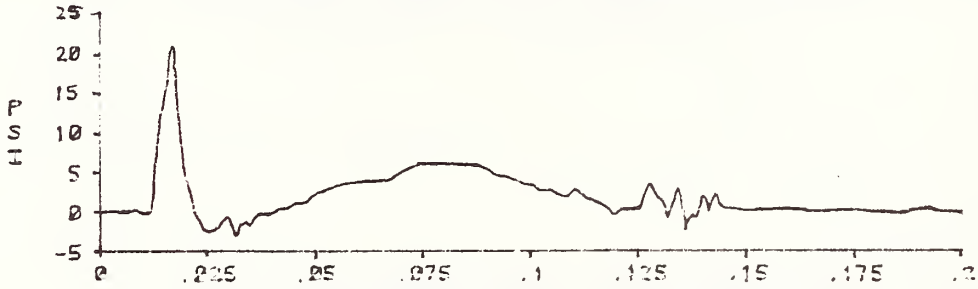

VOLVO 244 - 40 MPH
TEST 1868
JAN 13 81
20
0
-20
-40
-60
-80
-100
-120
-140
-160
G
S
0
.025
.05
.075
.1
.125
.15
.175
.2
CAR FIREWALL AP FC 60 VS TIME (SEC)
120
80
60
40
20
0
-20
-40
-60
-80
CUT WIRE
G
S
0
.025
.05
.075
.1
.125
.15
.175
.2
CAR RADIATOR X-MEMBER AP FC 60 VS TIME (SEC)

VOLVO 244 - 40 MPH

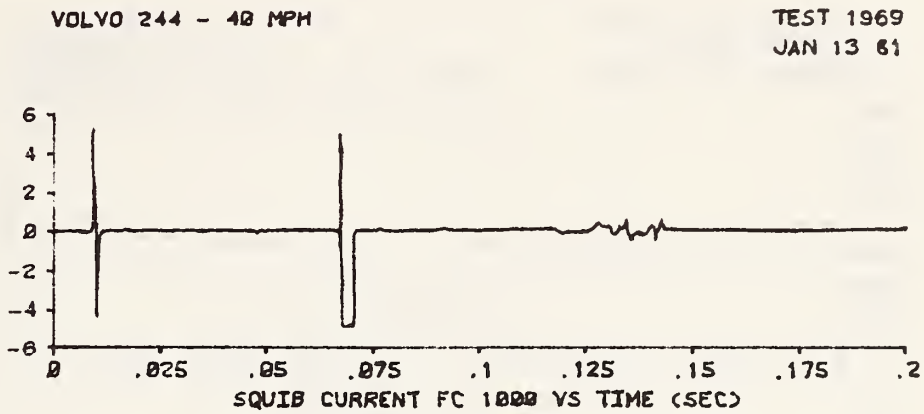
TEST 1969
JAN 13 81

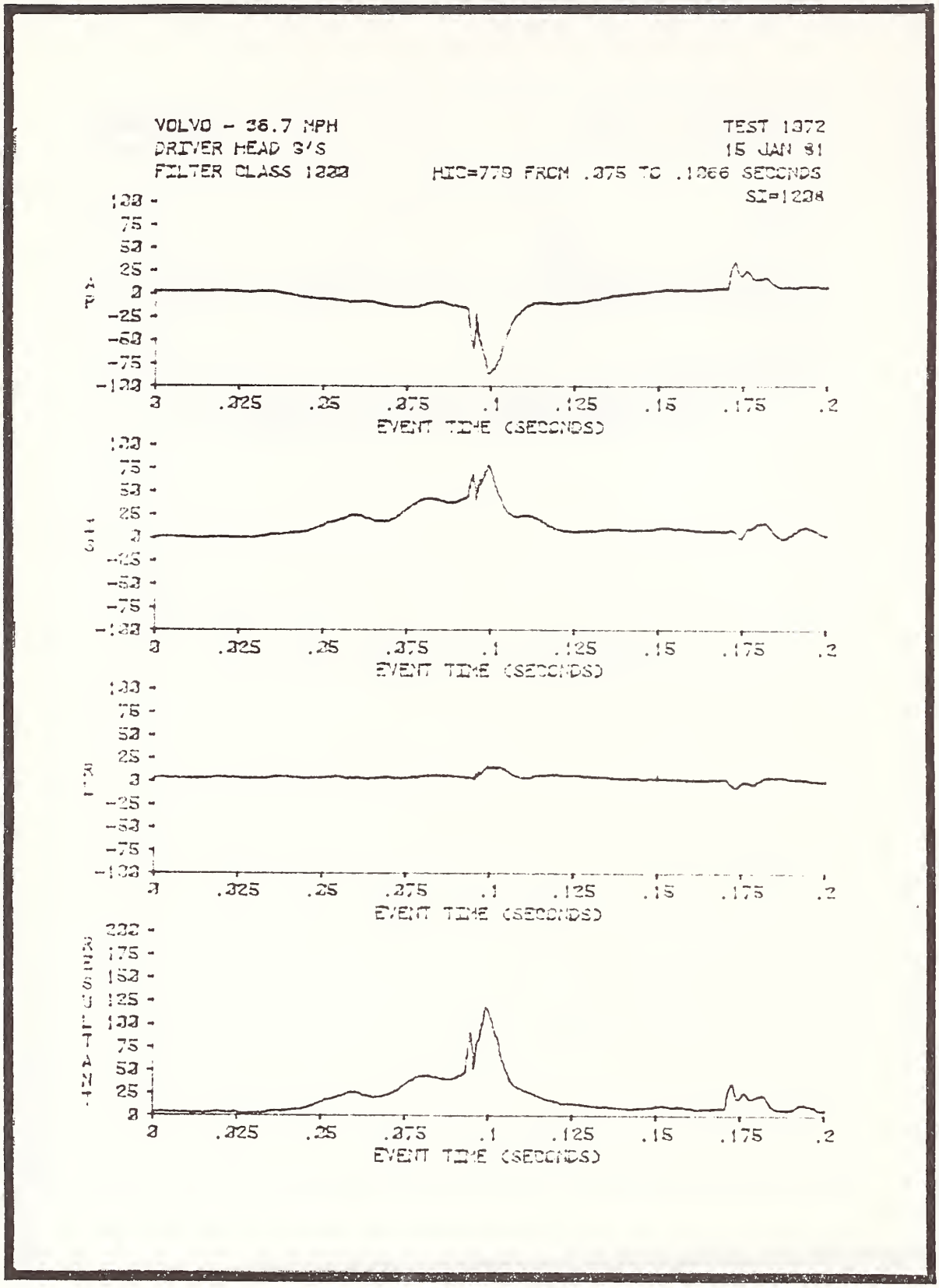


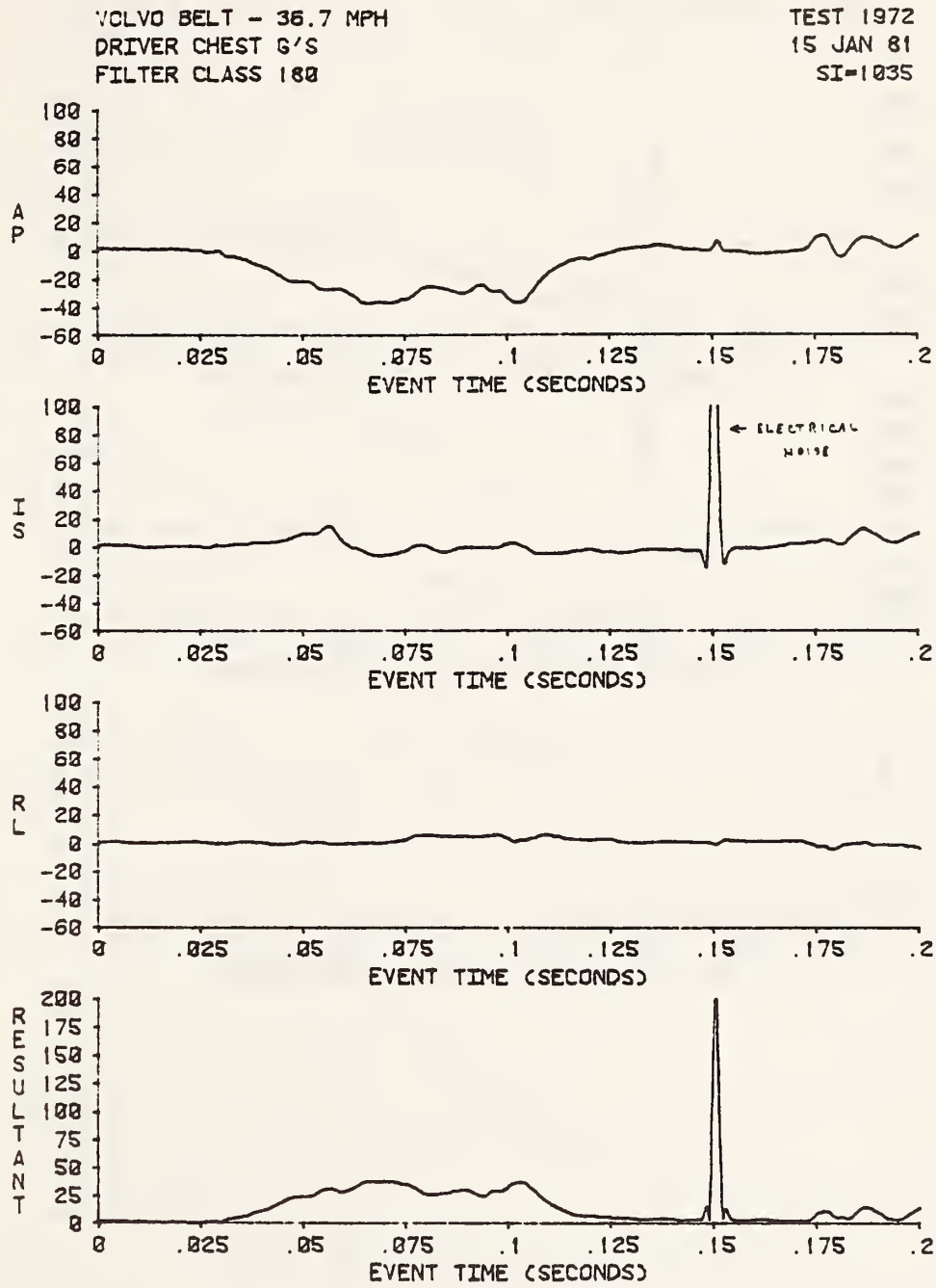
DRIVER BAG PRESSURE FC 180 VS TIME (SEC)

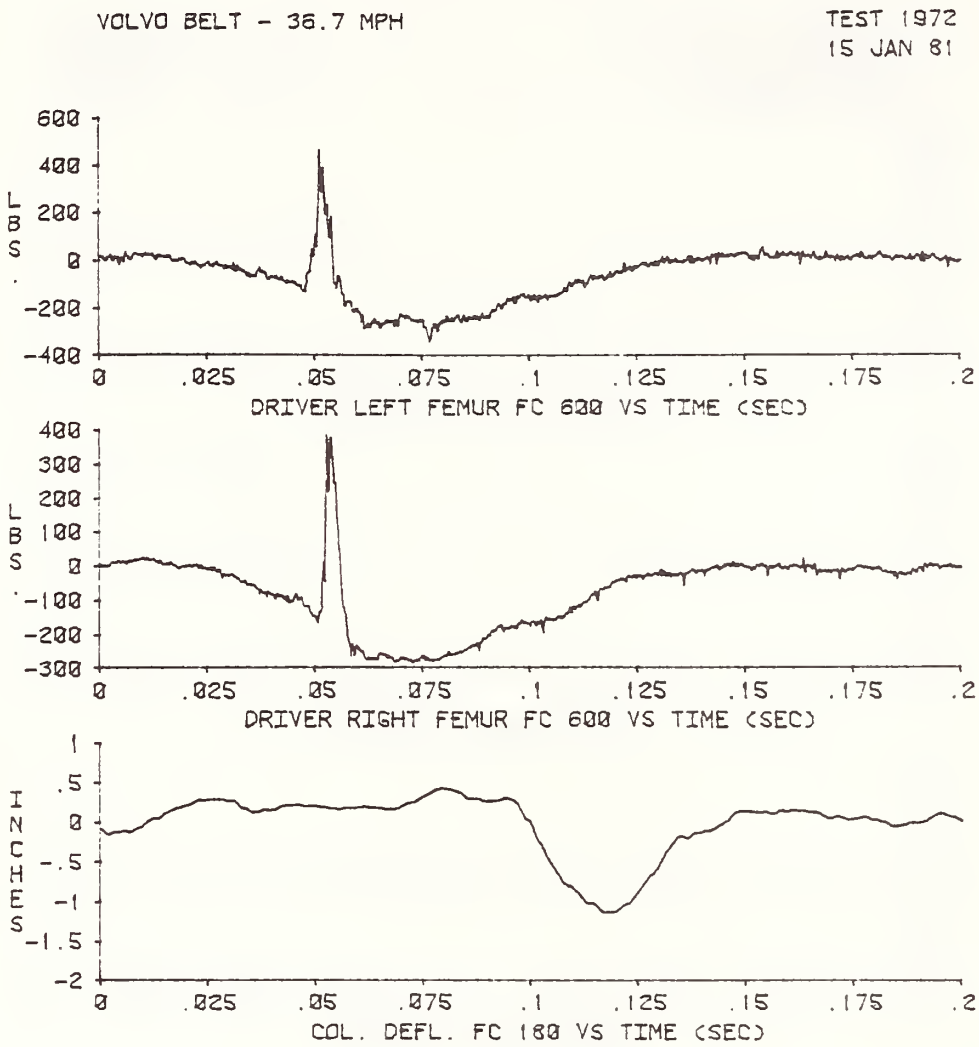


PASS. BAG PRESSURE FC 180 VS TIME (SEC)


VOLVO 244 - 40 MPH
TEST 1969
JAN 13 61
6
4
2
0
-2
-4
-6
0
.025
.05
.075
.1
.125
.15
.175
.2
SQUIB CURRENT FC 1000 VS TIME (SEC)

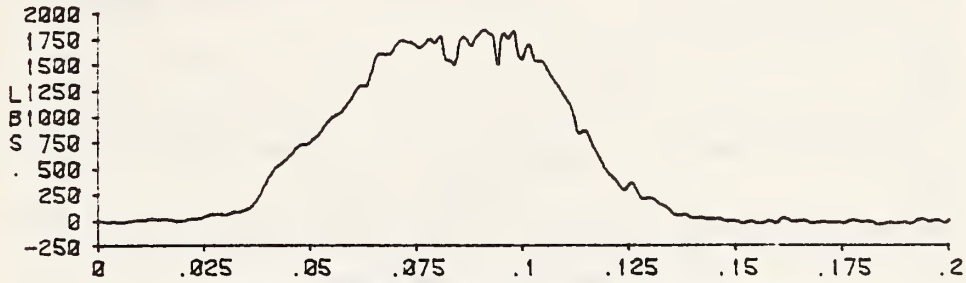

VOLVO - 36.7 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
TEST 1072
15 JAN 81
HIC=779 FROM .075 TO .1066 SECONDS
SI=1208
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)


VOLVO BELT - 36.7 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1972
15 JAN 81
SI=1035
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)
ELECTRICAL NOISE

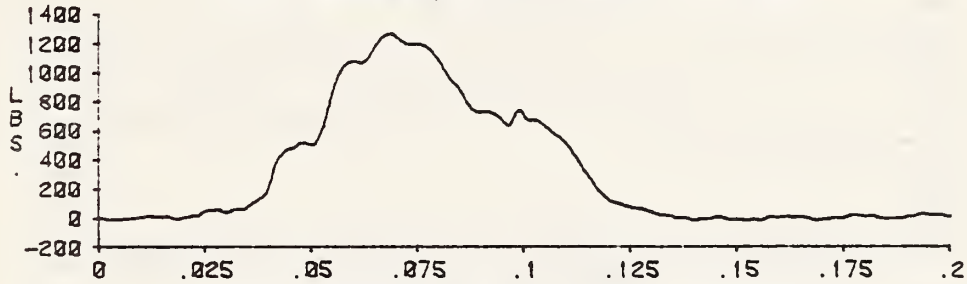

VOLVO BELT - 36.7 MPH
TEST 1972
15 JAN 81
LBS
600
400
200
0
-200
-400
0 .025 .05 .075 .1 .125 .15 .175 .2
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)
LBS
400
300
200
100
0
-100
-200
-300
0 .025 .05 .075 .1 .125 .15 .175 .2
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)
INCHES
1
.5
0
-.5
-1
-1.5
-2
0 .025 .05 .075 .1 .125 .15 .175 .2
COL. DEFL. FC 180 VS TIME (SEC)

VOLVO BELT - 36.7 MPH

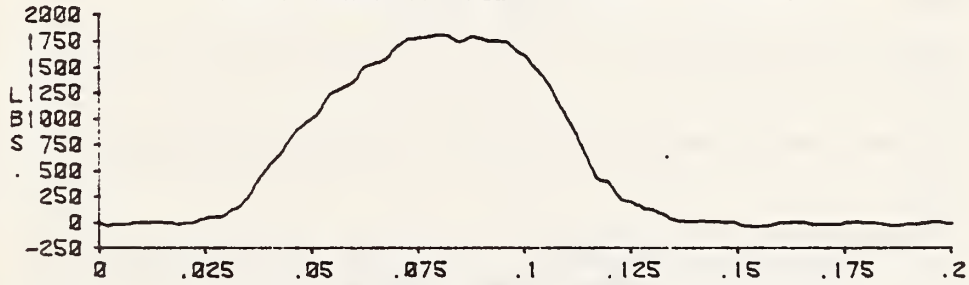
TEST 1972
15 JAN 81



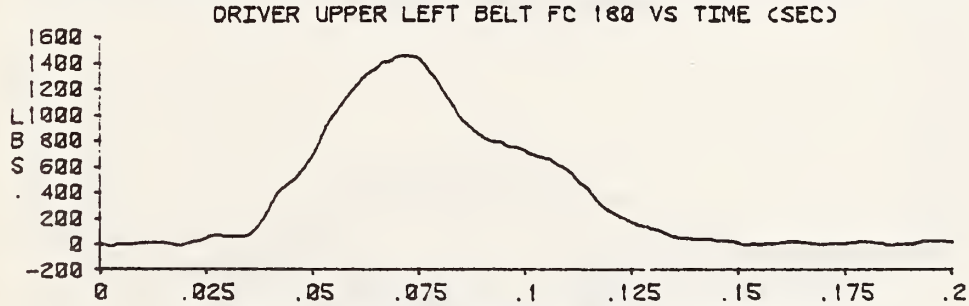
PASS. UPPER RT. BELT FC 180 VS TIME (SEC)



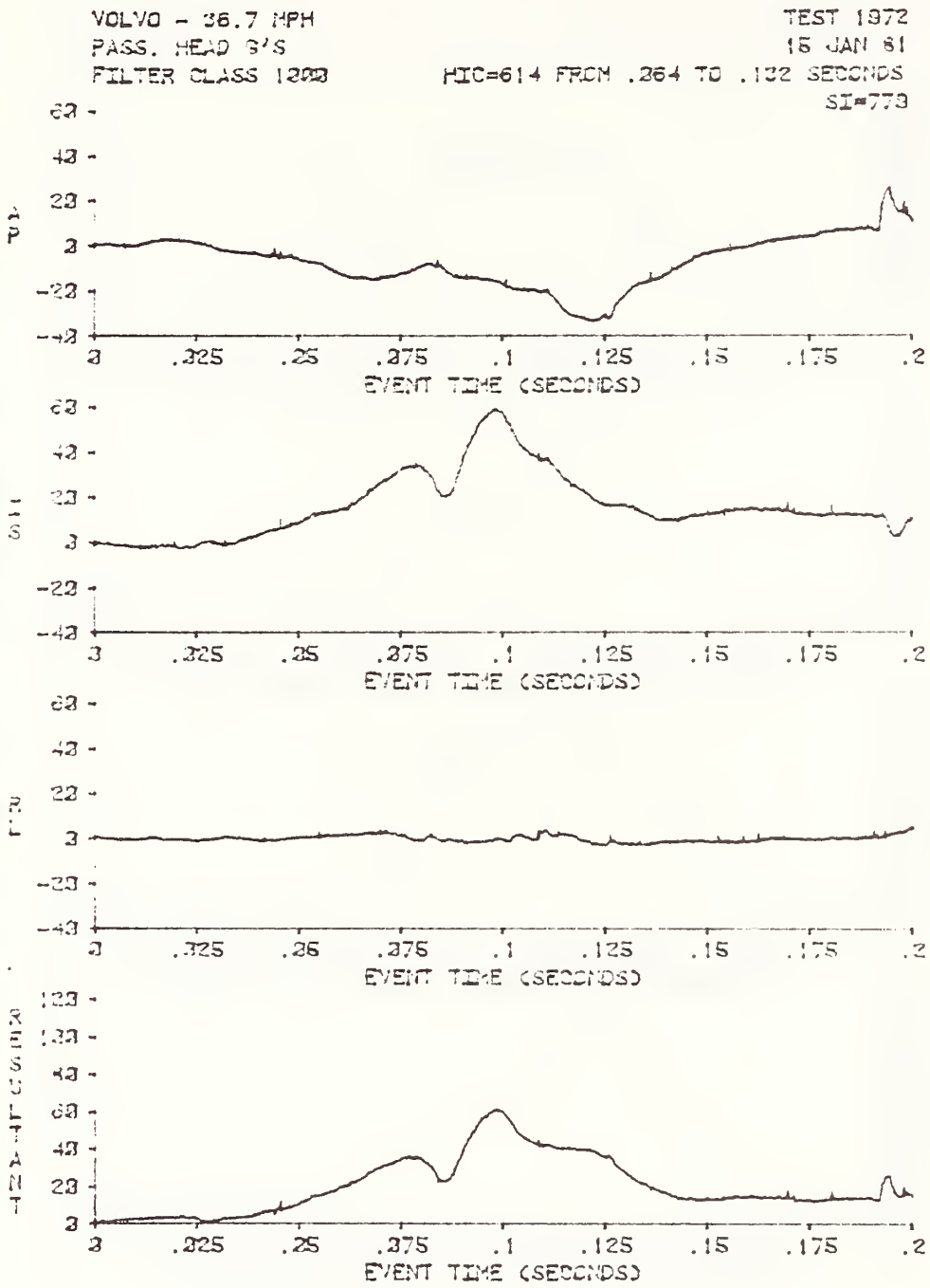
PASS. LOWER LEFT BELT FC 180 VS TIME (SEC)

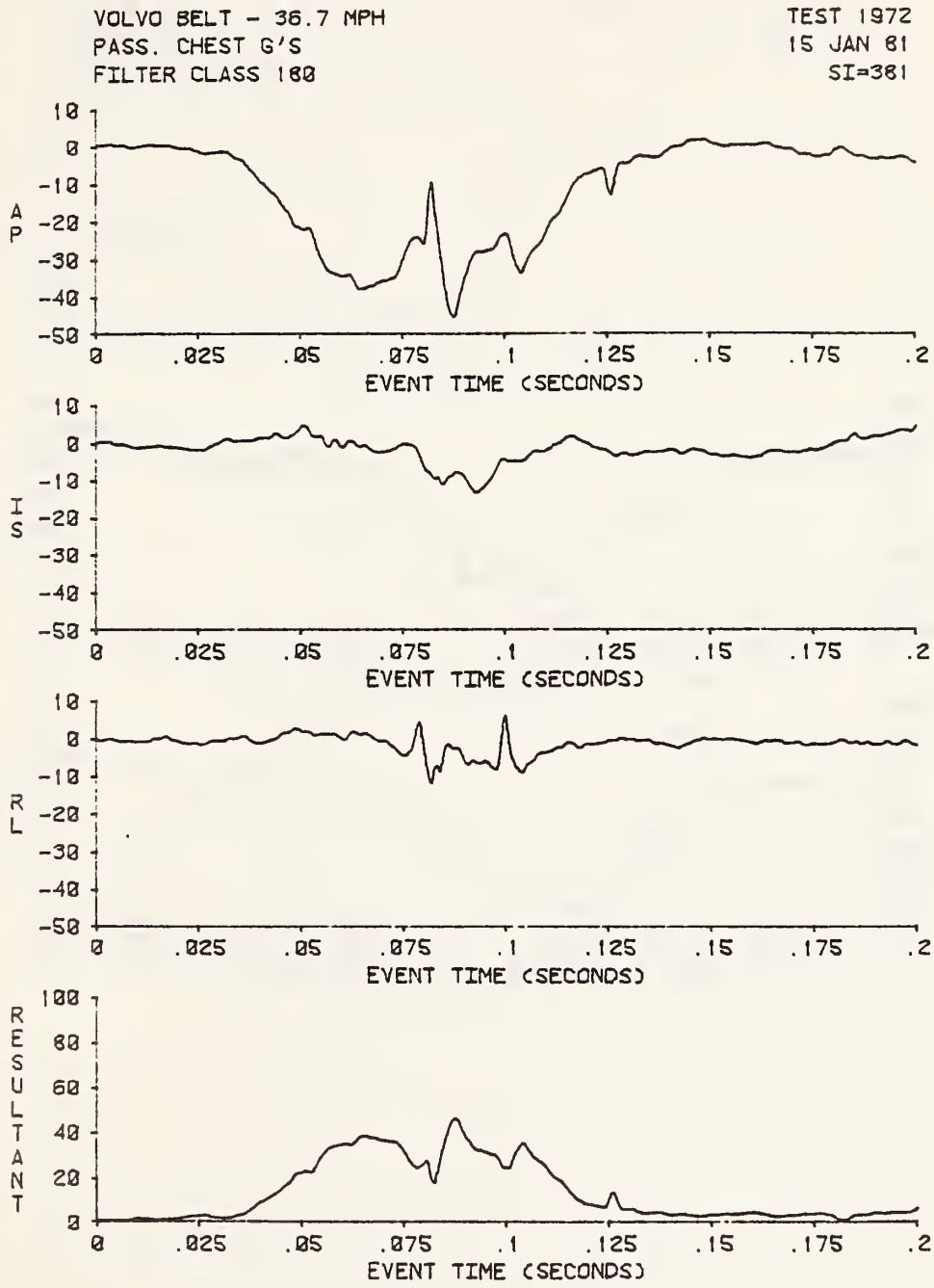


DRIVER UPPER LEFT BELT FC 180 VS TIME (SEC)



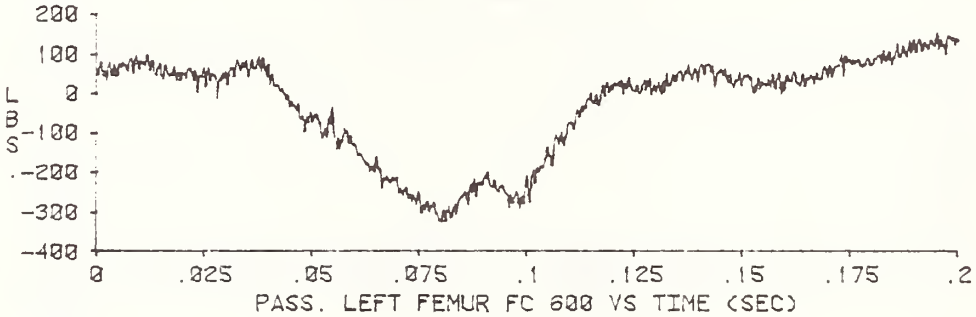
DRIVER LOWER LEFT BELT FC 180 VS TIME (SEC)

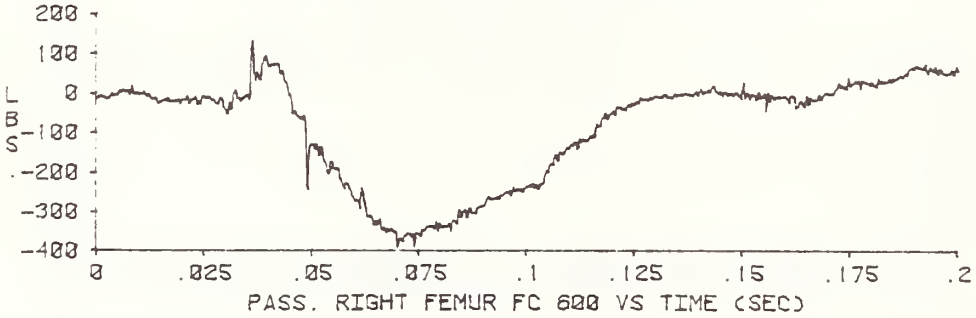

VOLVO - 36.7 MPH
PASS. HEAD G'S
FILTER CLASS 1000
TEST 1972
15 JAN 81
HIC=614 FROM .264 TO .122 SECONDS
SI=773
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)

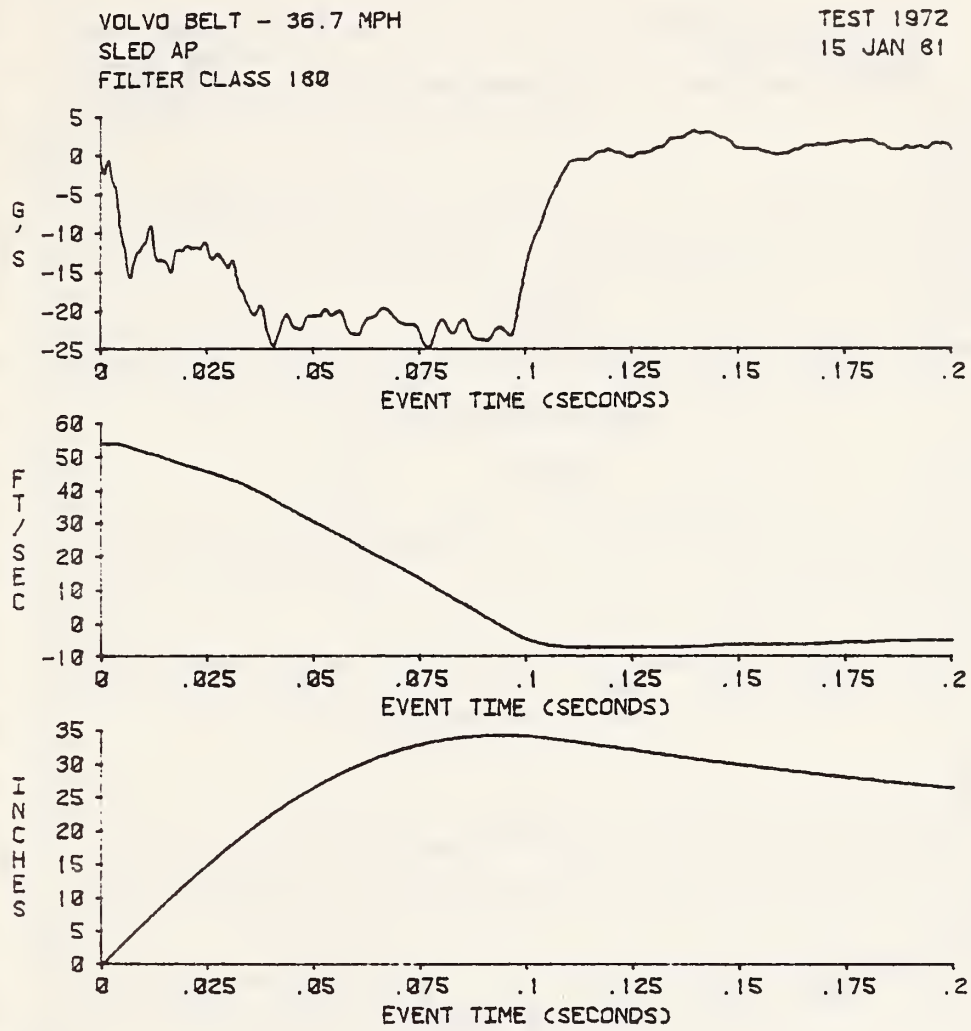

VOLVO BELT - 36.7 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1972
15 JAN 81
SI=381
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

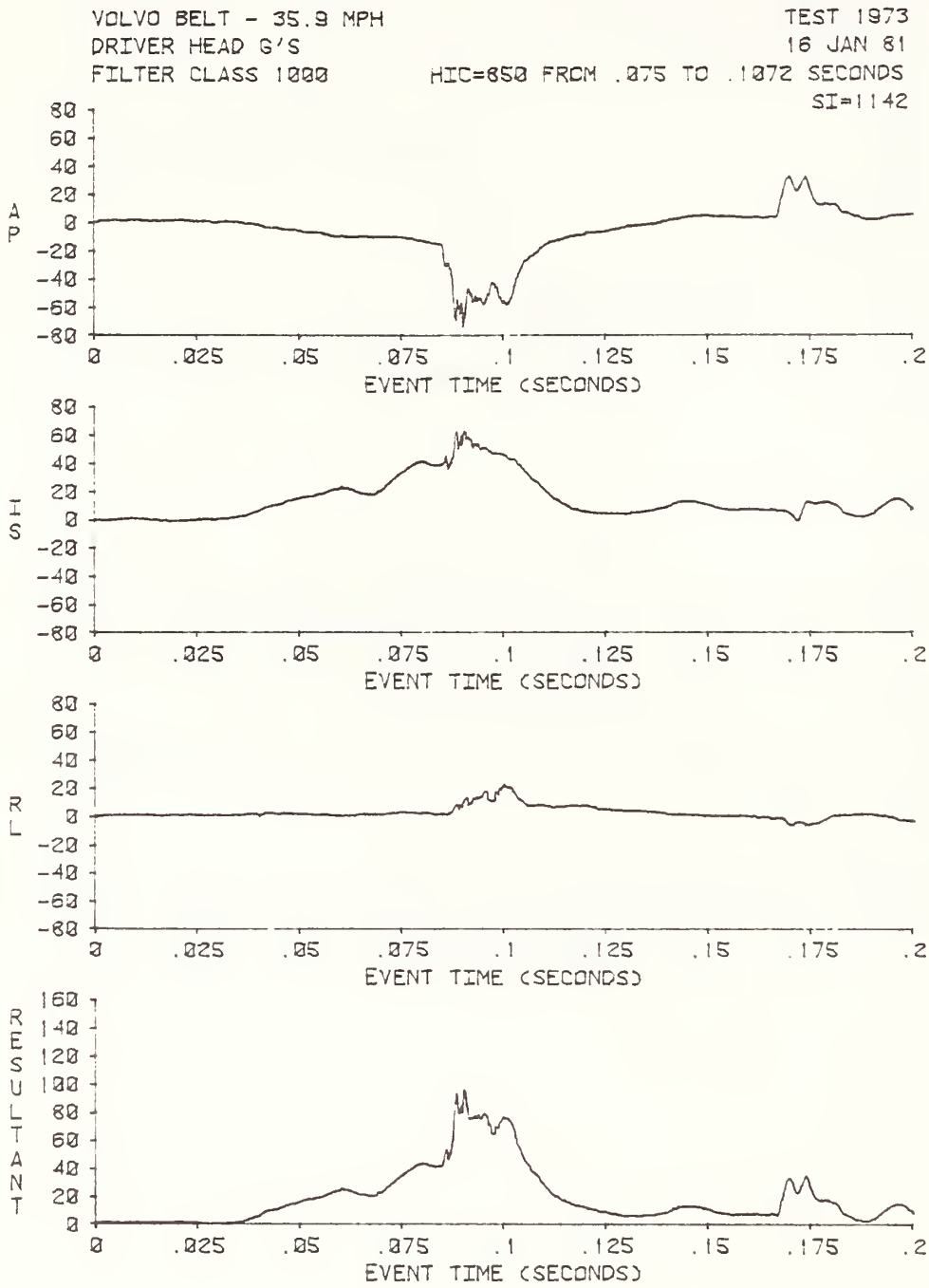
VOLVO BELT - 36.7 MPH

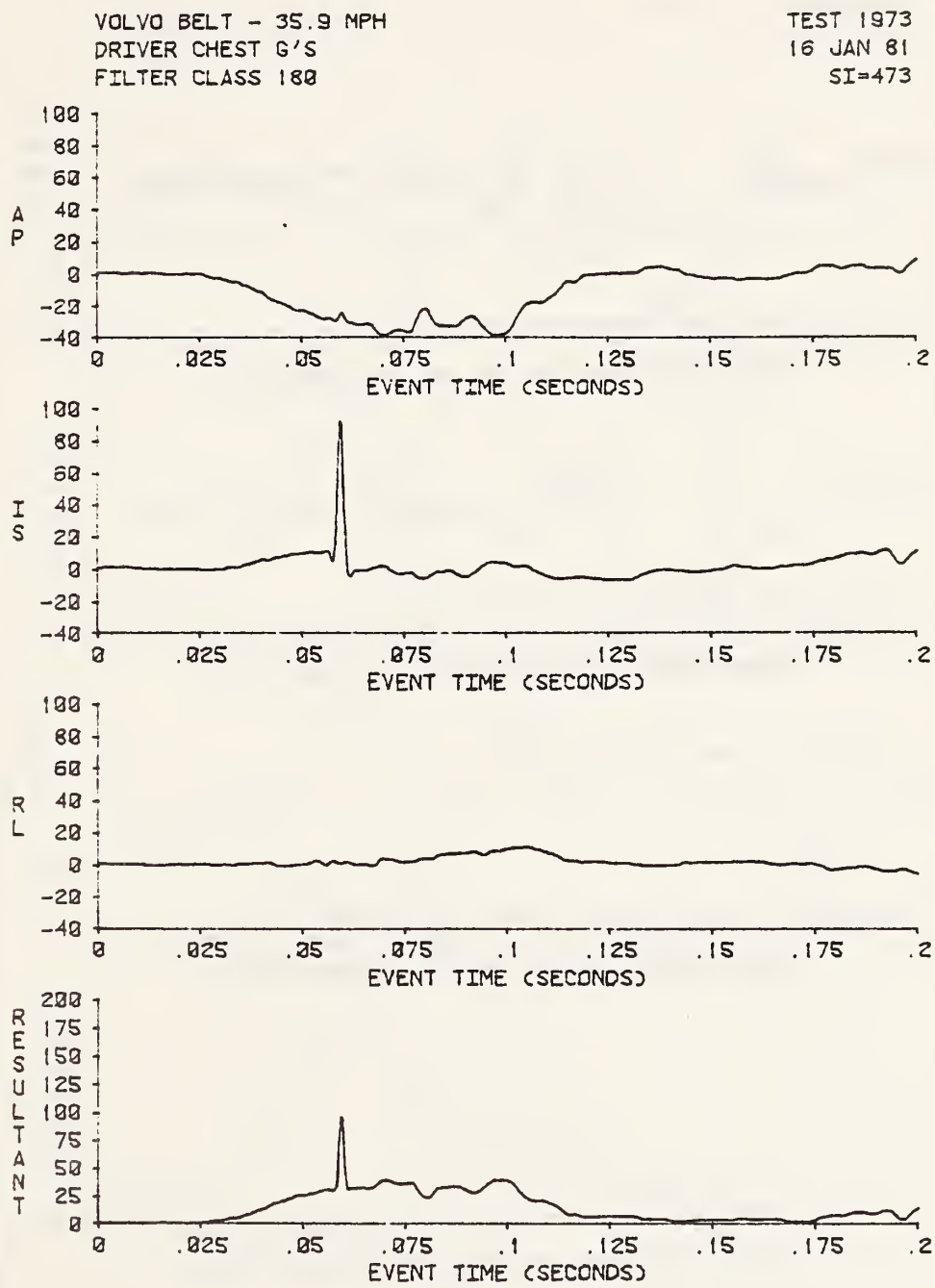
TEST 1972
15 JAN 81





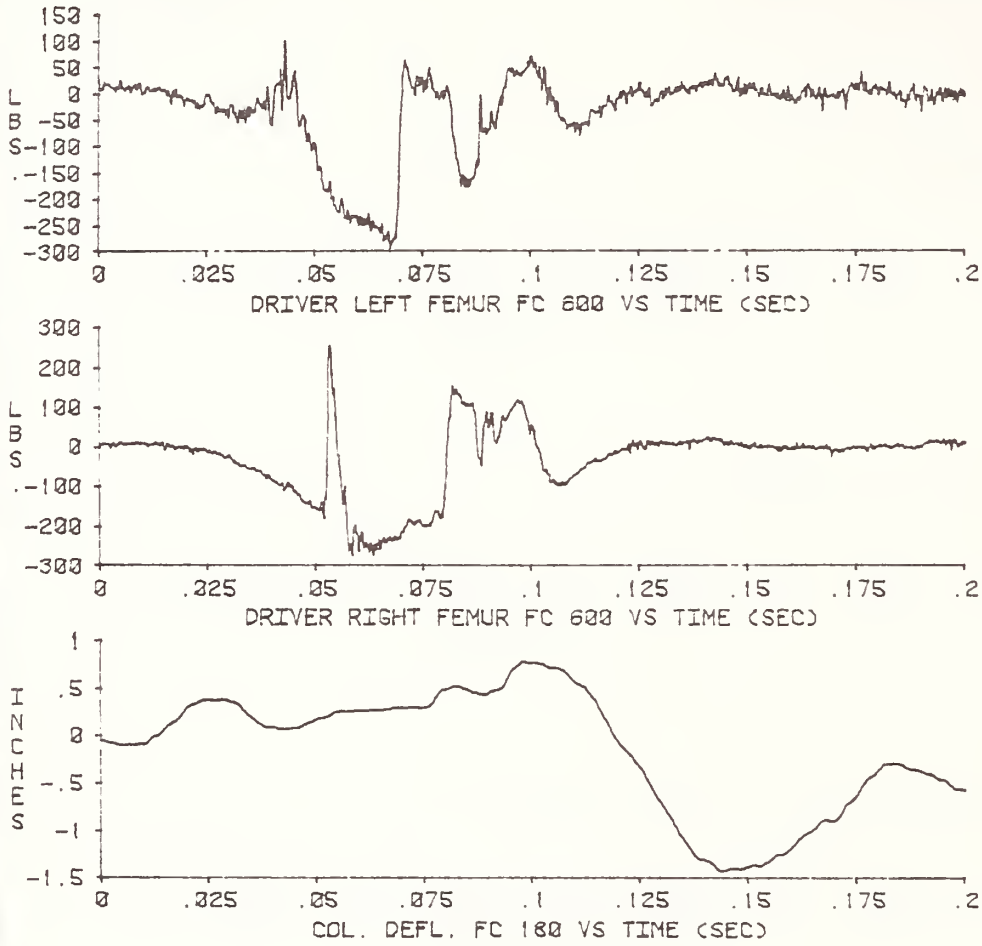

VOLVO BELT - 36.7 MPH
SLED AP
FILTER CLASS 180
TEST 1972
15 JAN 81
G'S
5
0
-5
-10
-15
-20
-25
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)


VOLVO BELT - 35.9 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=650 FROM .075 TO .1072 SECONDS
SI=1142
TEST 1973
16 JAN 81
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO BELT - 35.9 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1973
16 JAN 81
SI=473
AP
IS
RL
RESULTANT
100
80
60
40
20
0
-20
-40
200
175
150
125
100
75
50
25
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

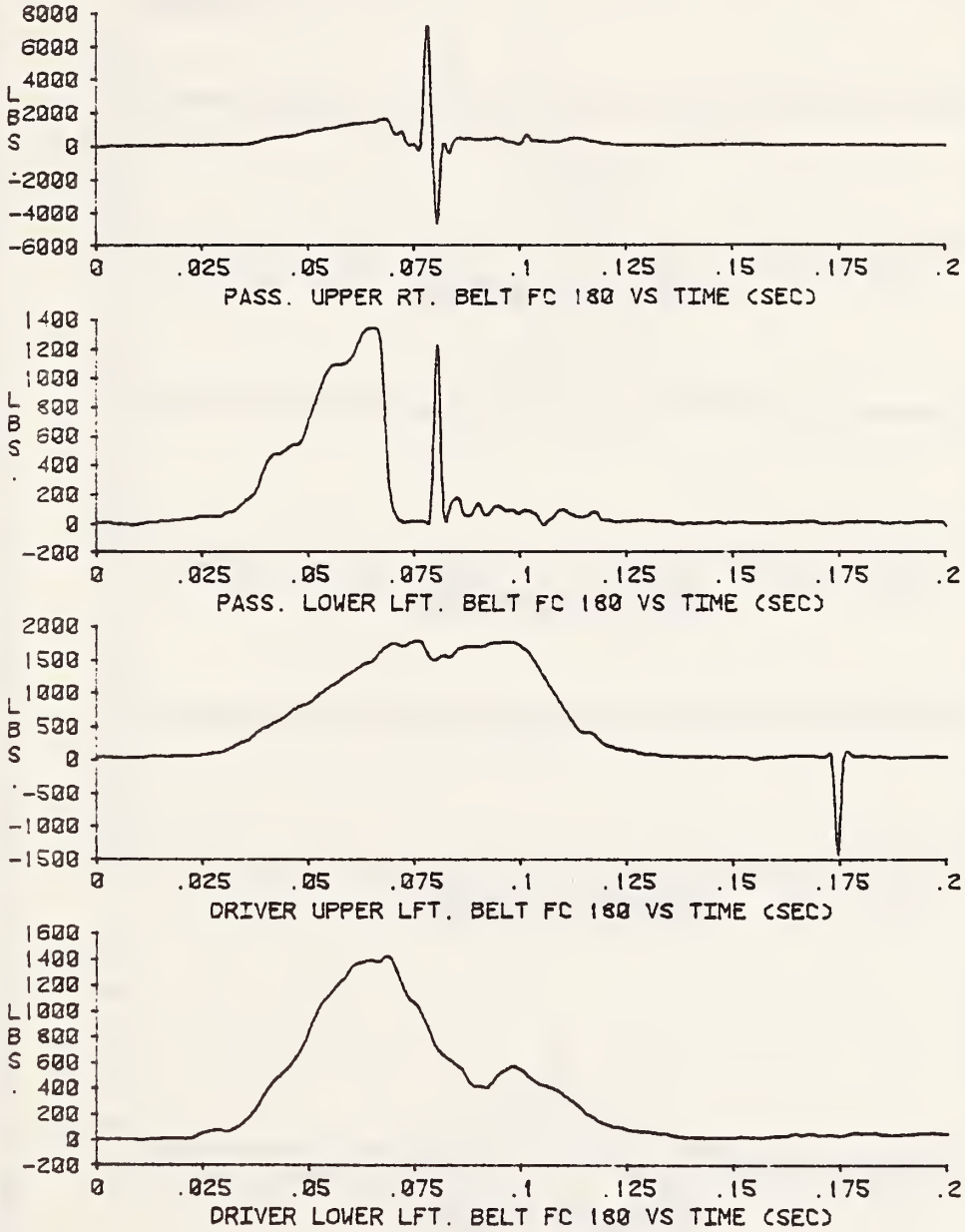
VOLVO BELT - 35.9 MPH

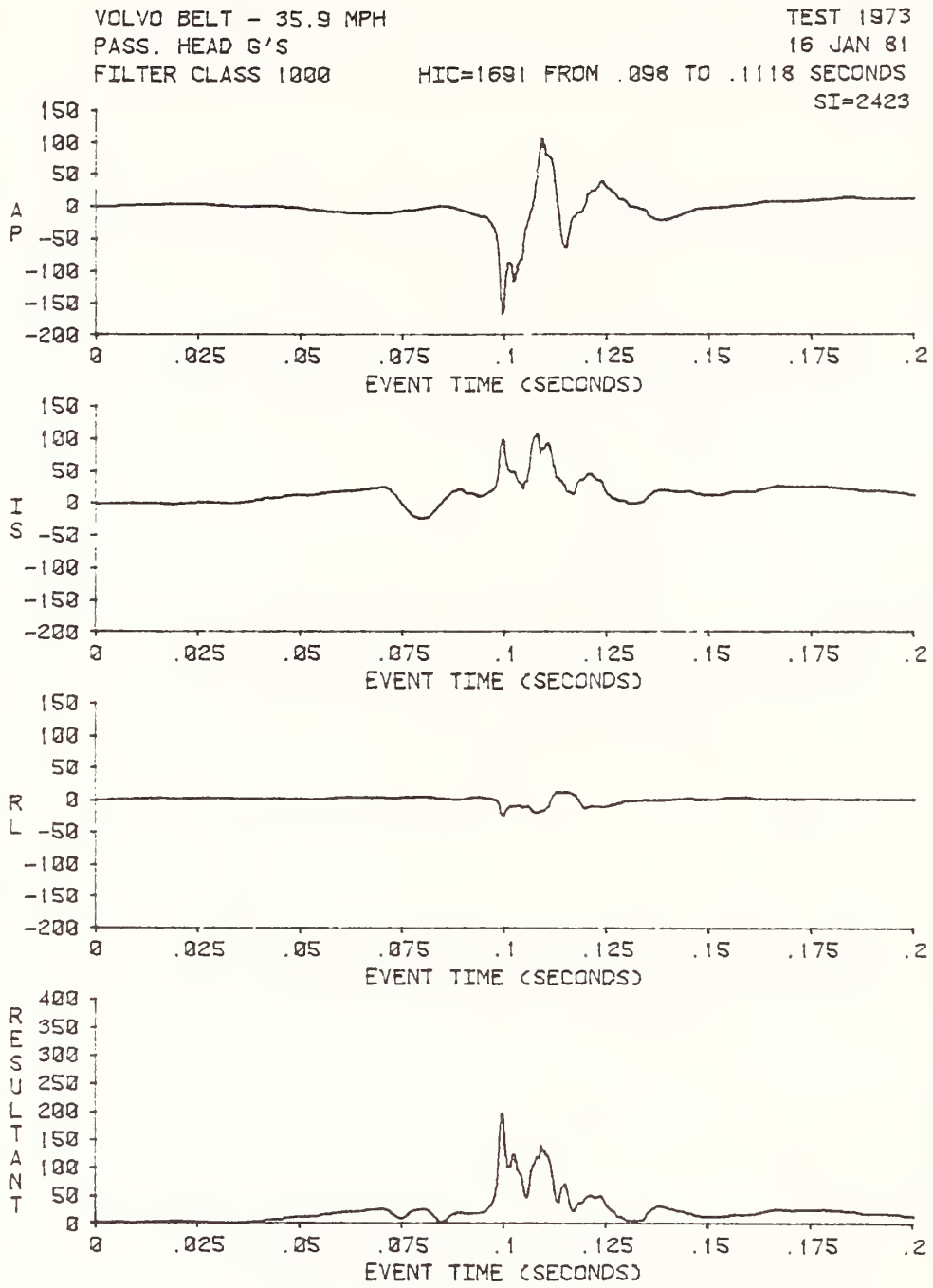
TEST 1973
16 JAN 81

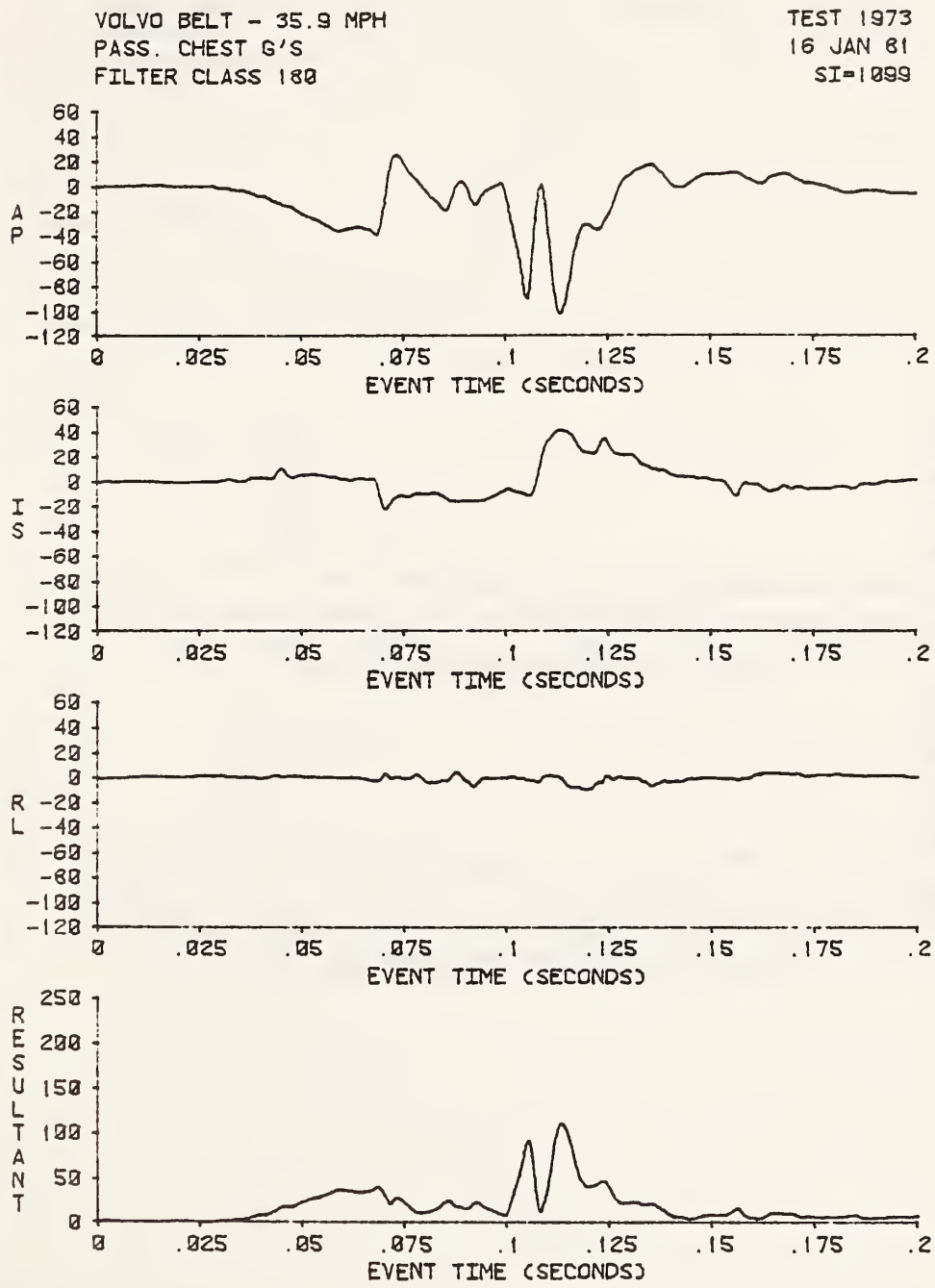


VOLVO BELT - 35.9 MPH

TEST 1973
16 JAN 81

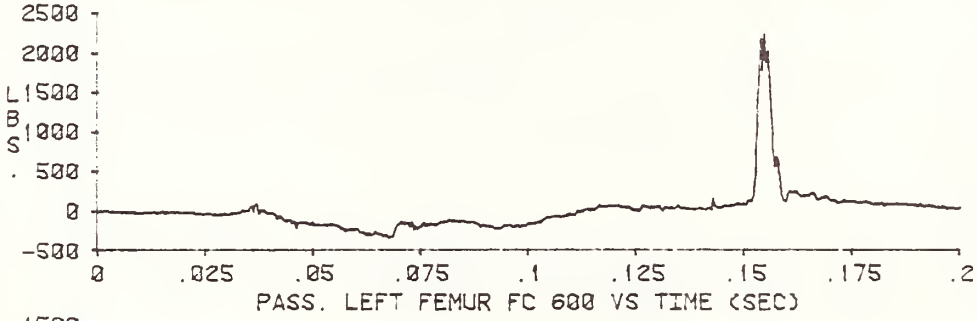



VOLVO BELT - 35.9 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=1691 FROM .098 TO .1118 SECONDS
TEST 1973
16 JAN 81
SI=2423
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

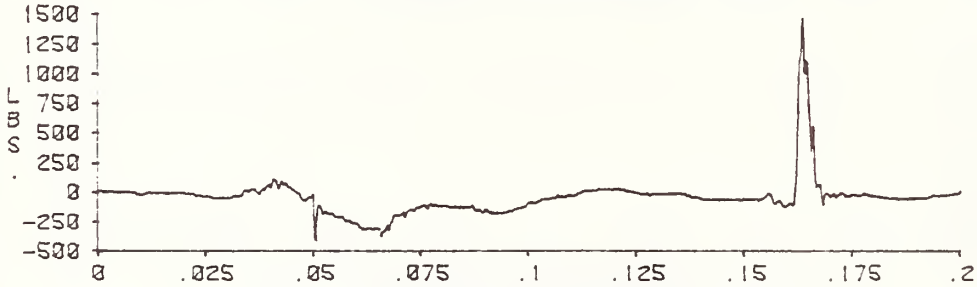

VOLVO BELT - 35.9 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1973
16 JAN 81
SI=1099
A P
I S
R L
RESULTANT
EVENT TIME (SECONDS)

VOLVO BELT - 35.9 MPH

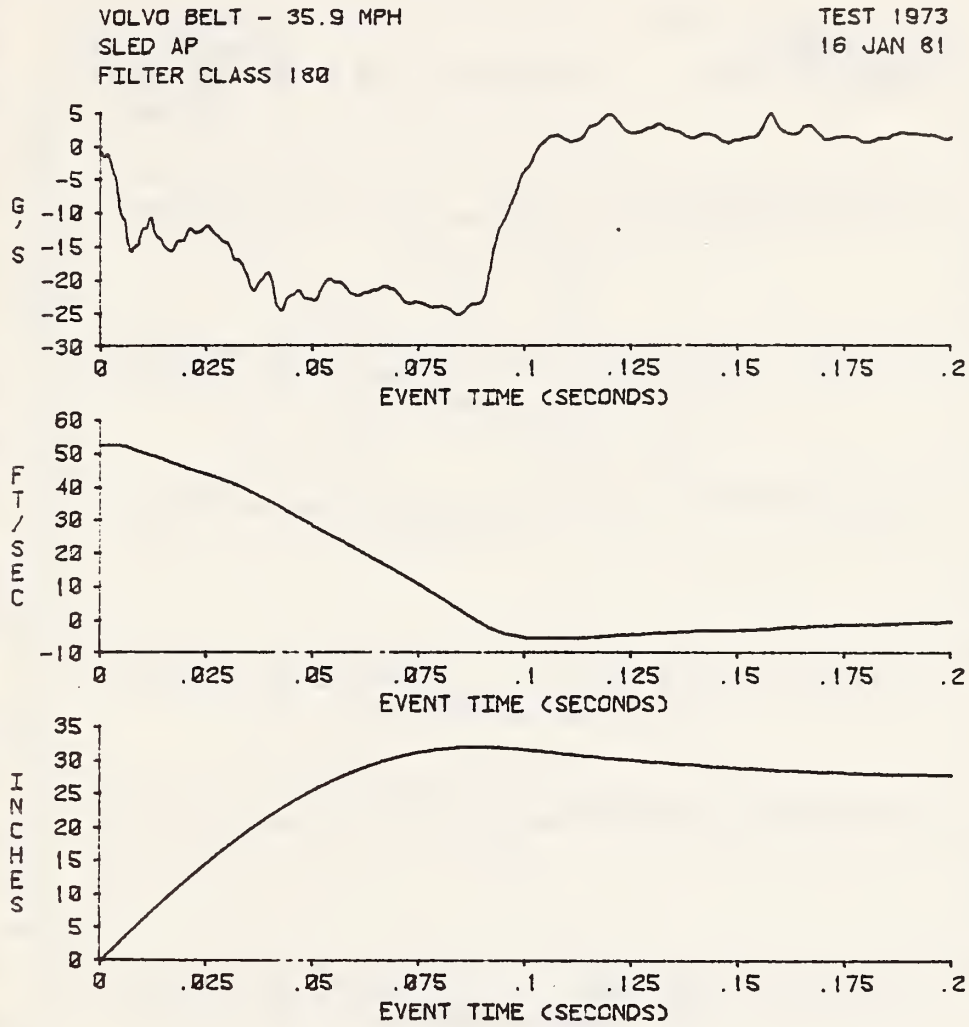
TEST 1973
16 JAN 81

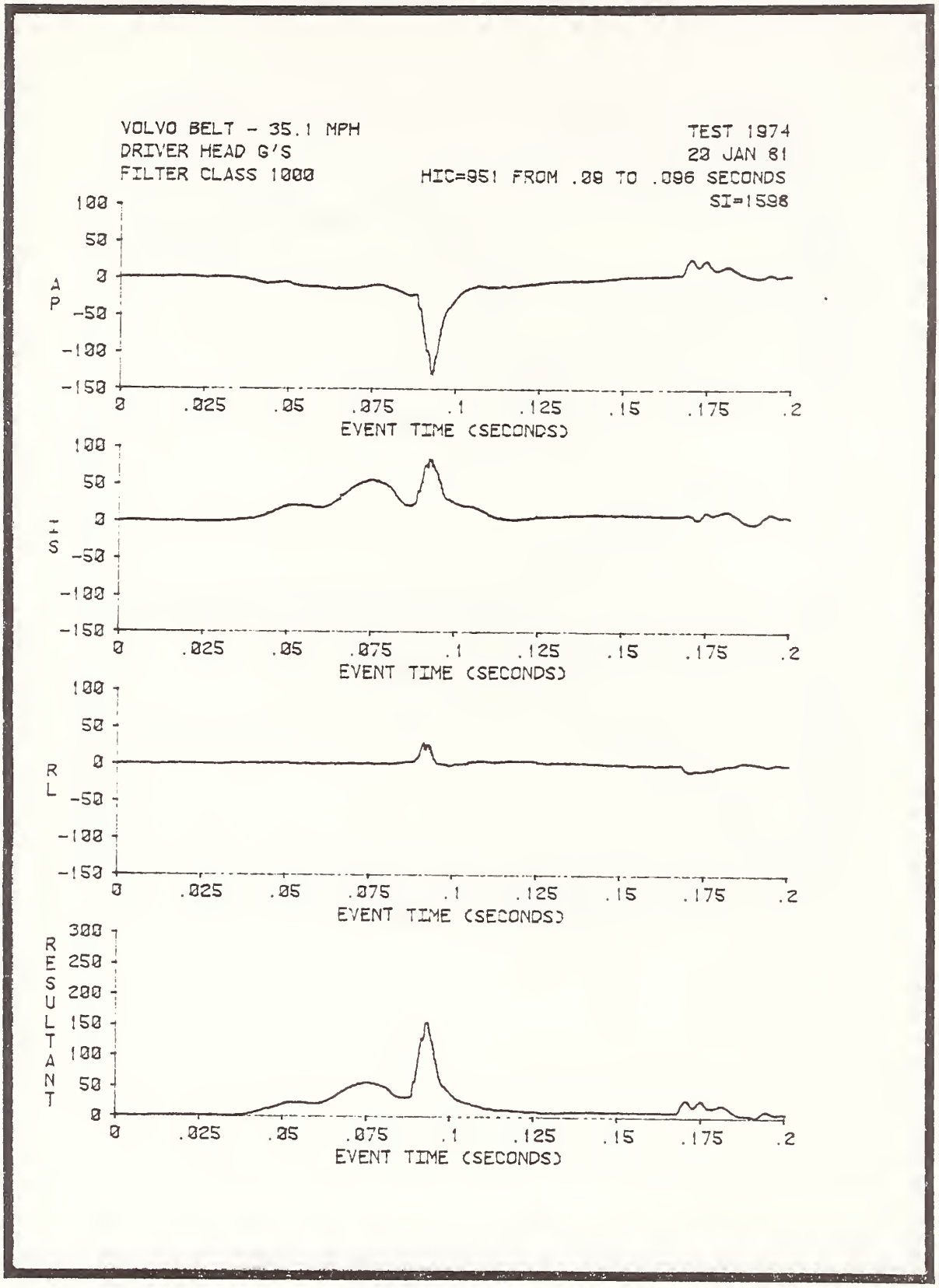


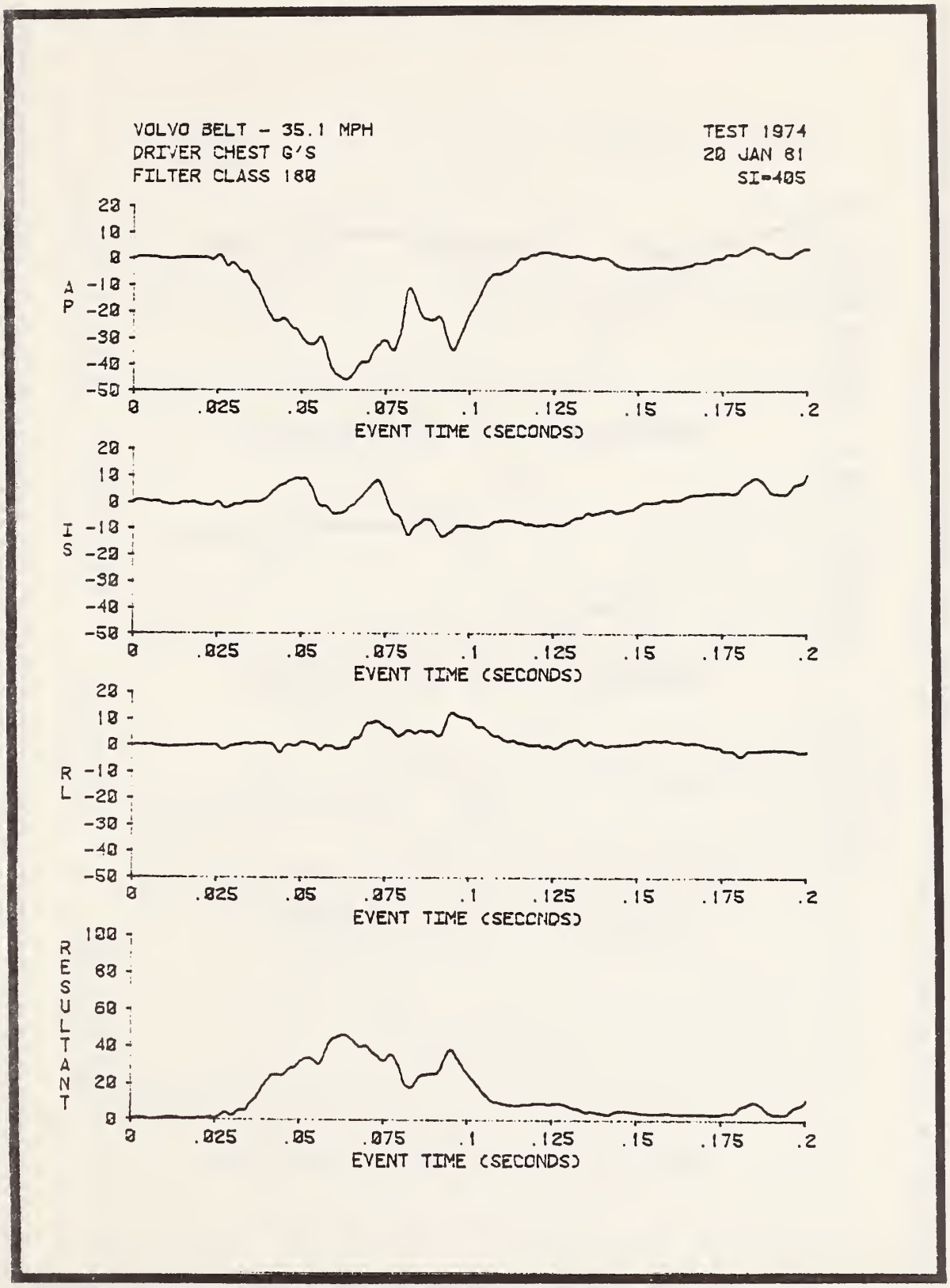
PASS. LEFT FEMUR FC 600 VS TIME (SEC)



PASS. RIGHT FEMUR FC 600 VS TIME (SEC)

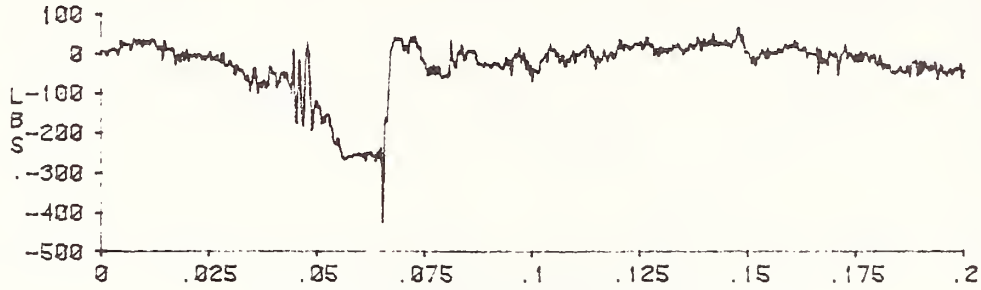

VOLVO BELT - 35.9 MPH
SLED AP
FILTER CLASS 180
TEST 1973
16 JAN 81
G'S
5
0
-5
-10
-15
-20
-25
-30
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)


VOLVO BELT - 35.1 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
TEST 1974
20 JAN 81
HIC=951 FROM .08 TO .096 SECONDS
SI=1598
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)

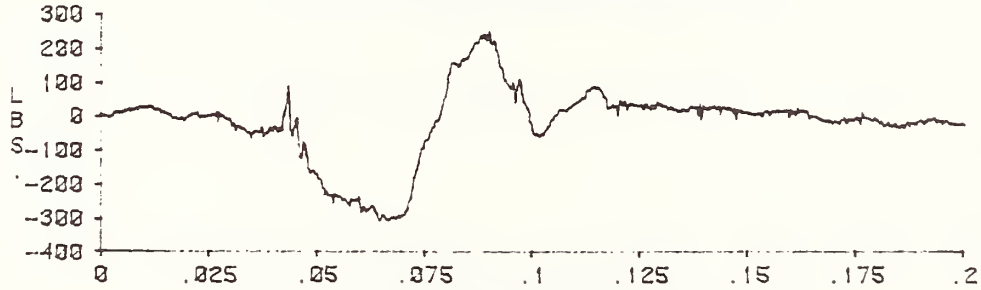

VOLVO BELT - 35.1 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1974
20 JAN 81
SI=405
AP
IS
RL
RESULTANT
20
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

VOLVO BELT - 35.1 MPH

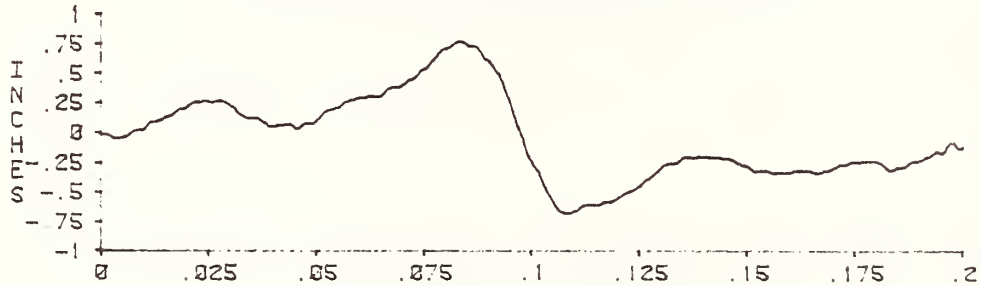
TEST 1974
20 JAN 81



DRIVER LEFT FEMUR FC 600 VS TIME (SEC)



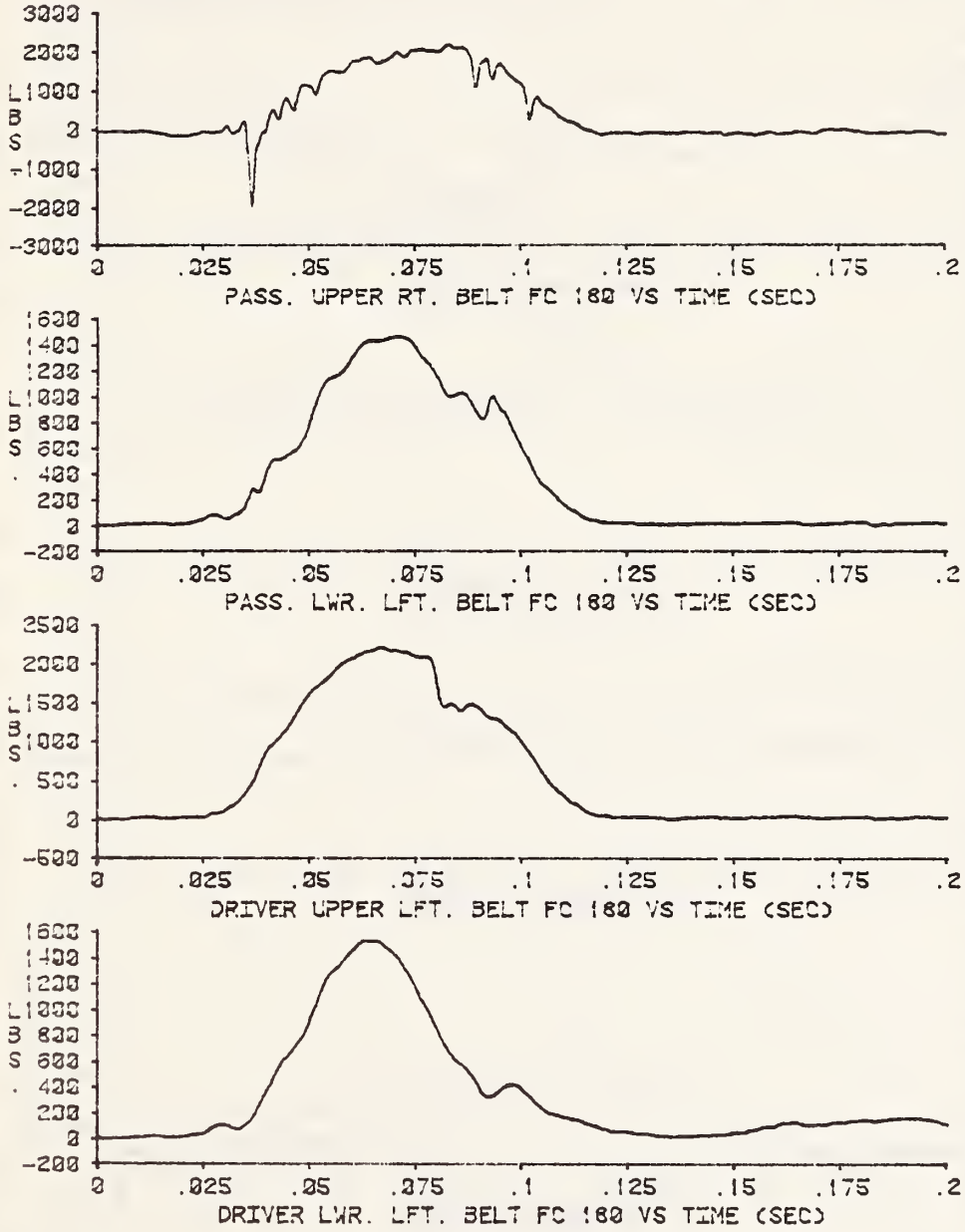
DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)

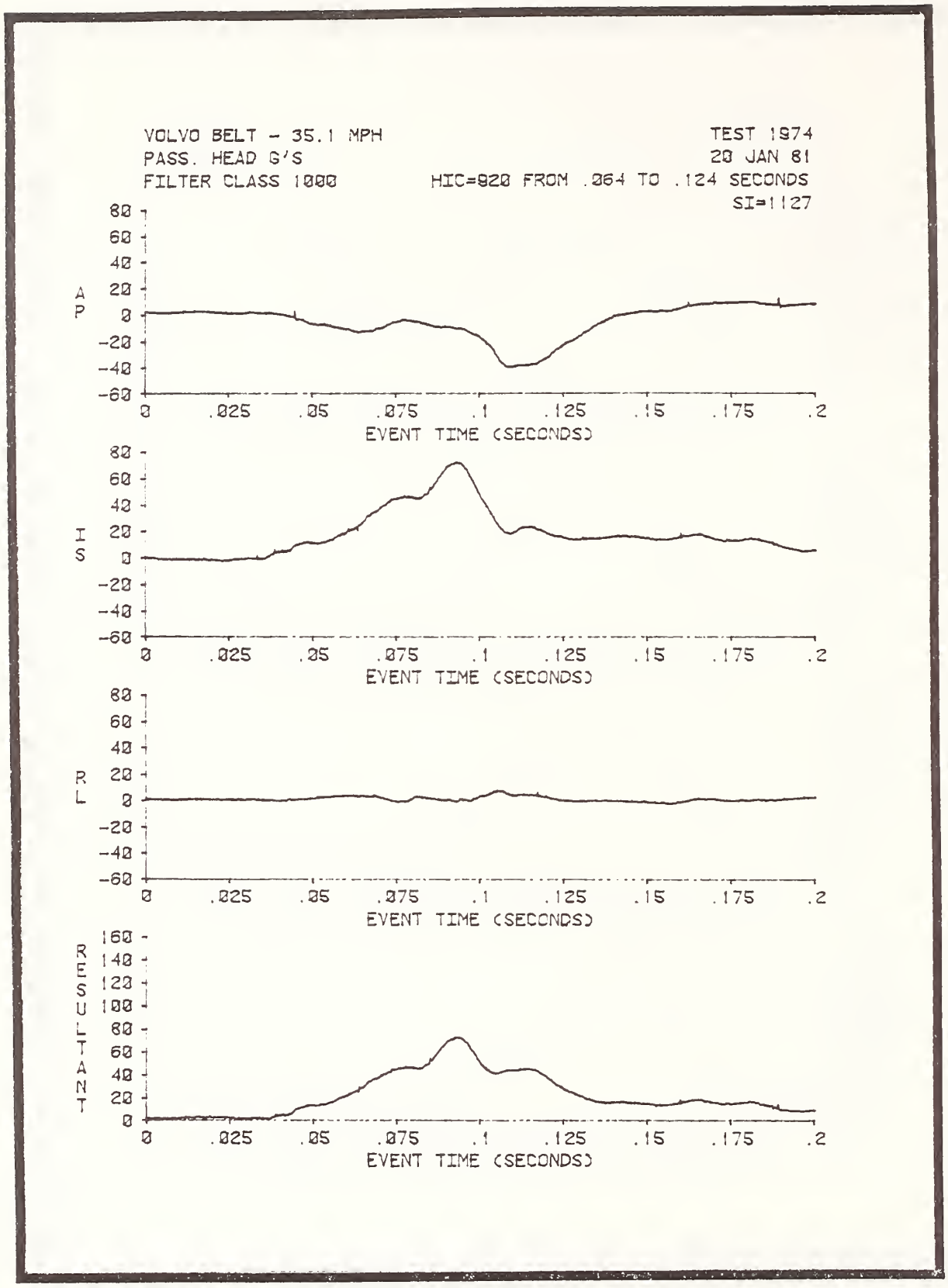


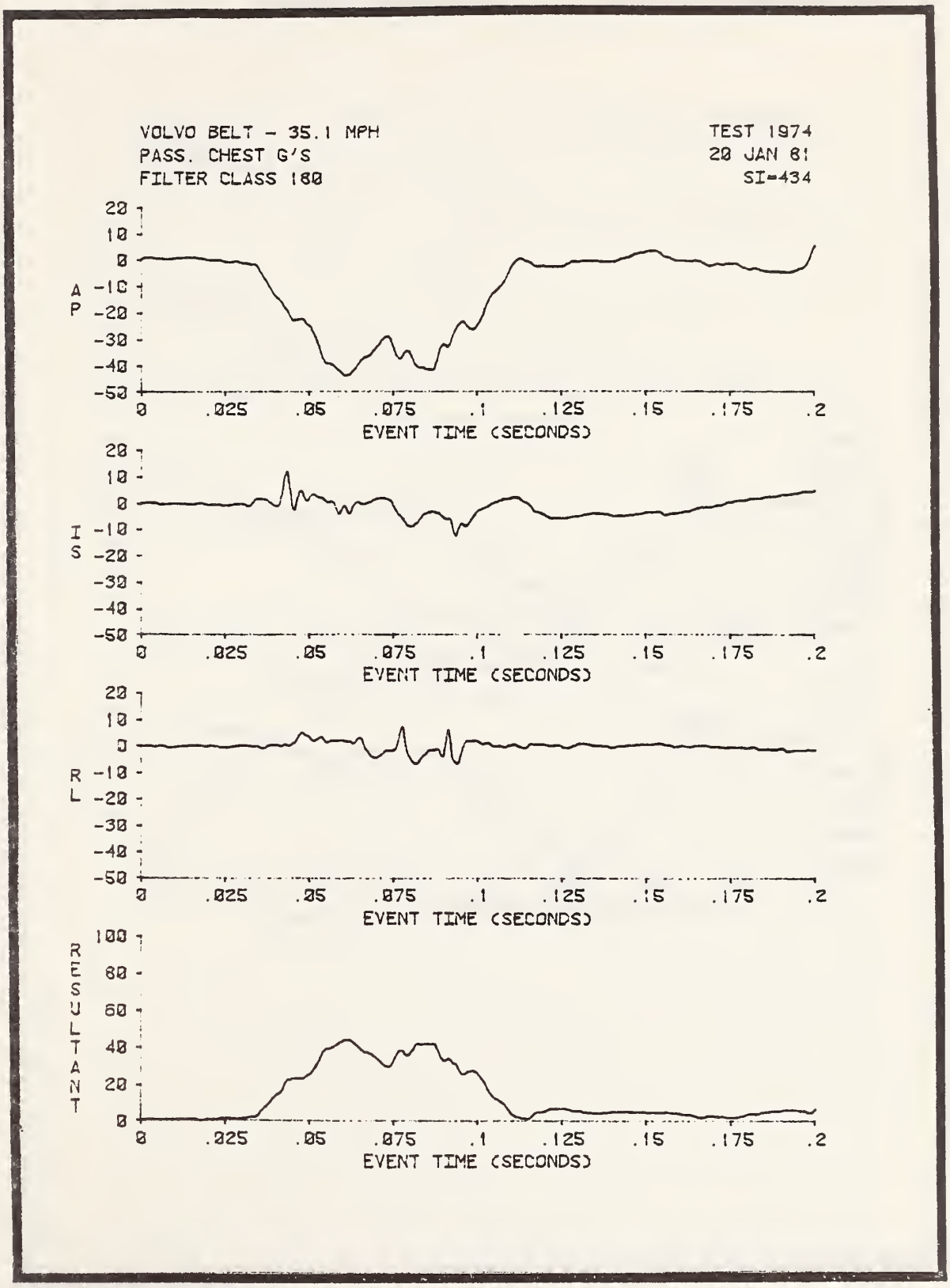
COL. DEFL. FC 180 VS TIME (SEC)

VOLVO BELT - 35.1 MPH

TEST 1974
20 JAN 81

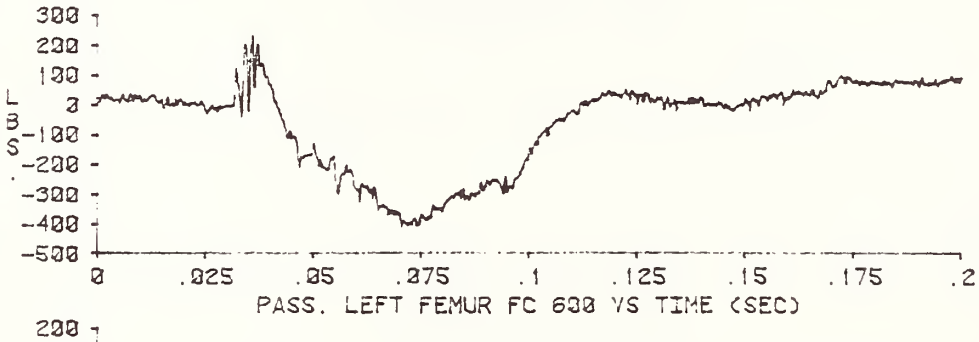


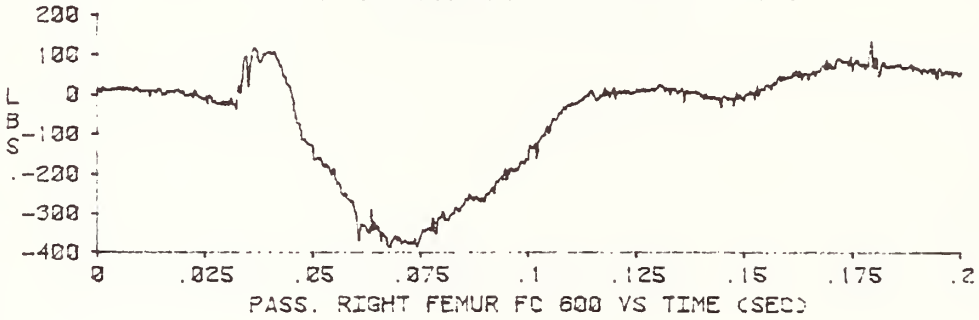

VOLVO BELT - 35.1 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=920 FROM .064 TO .124 SECONDS
TEST 1974
20 JAN 81
SI=1127
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

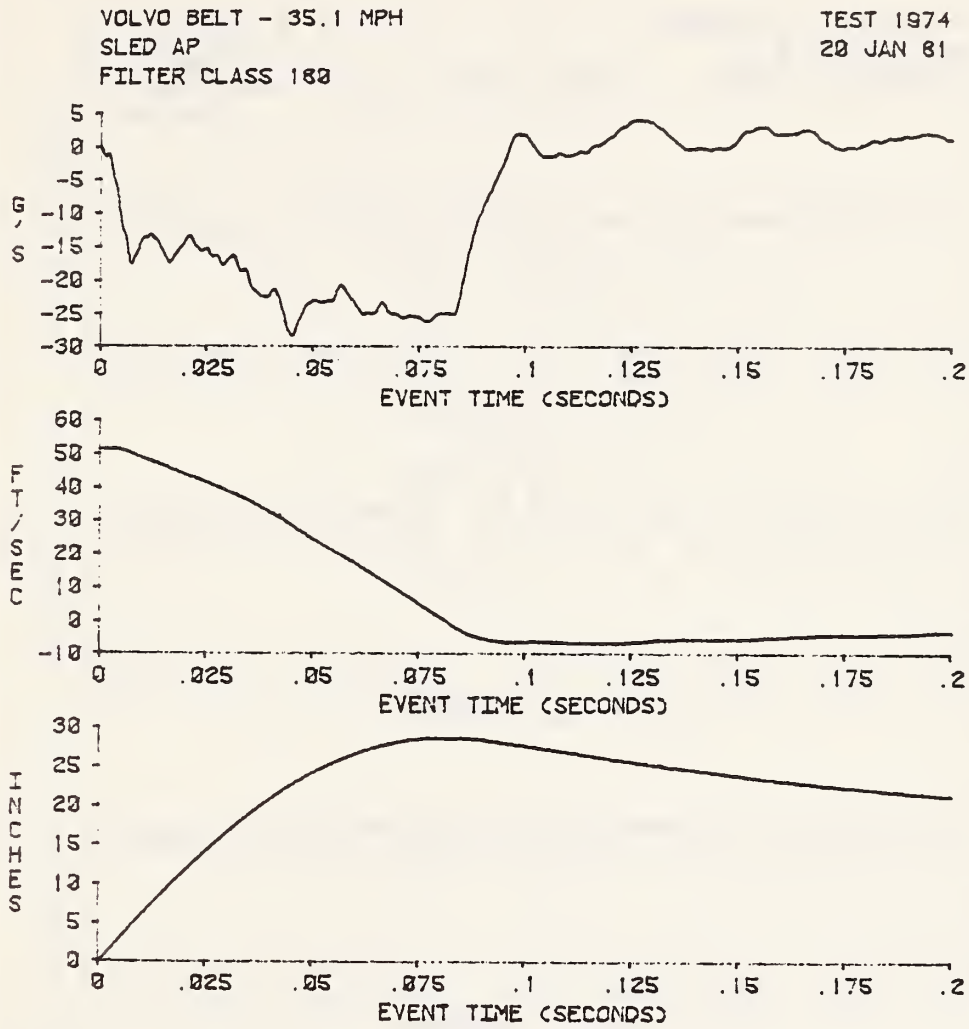

VOLVO BELT - 35.1 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1974
20 JAN 81
SI=434
AP
IS
RL
RESULTANT
20
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

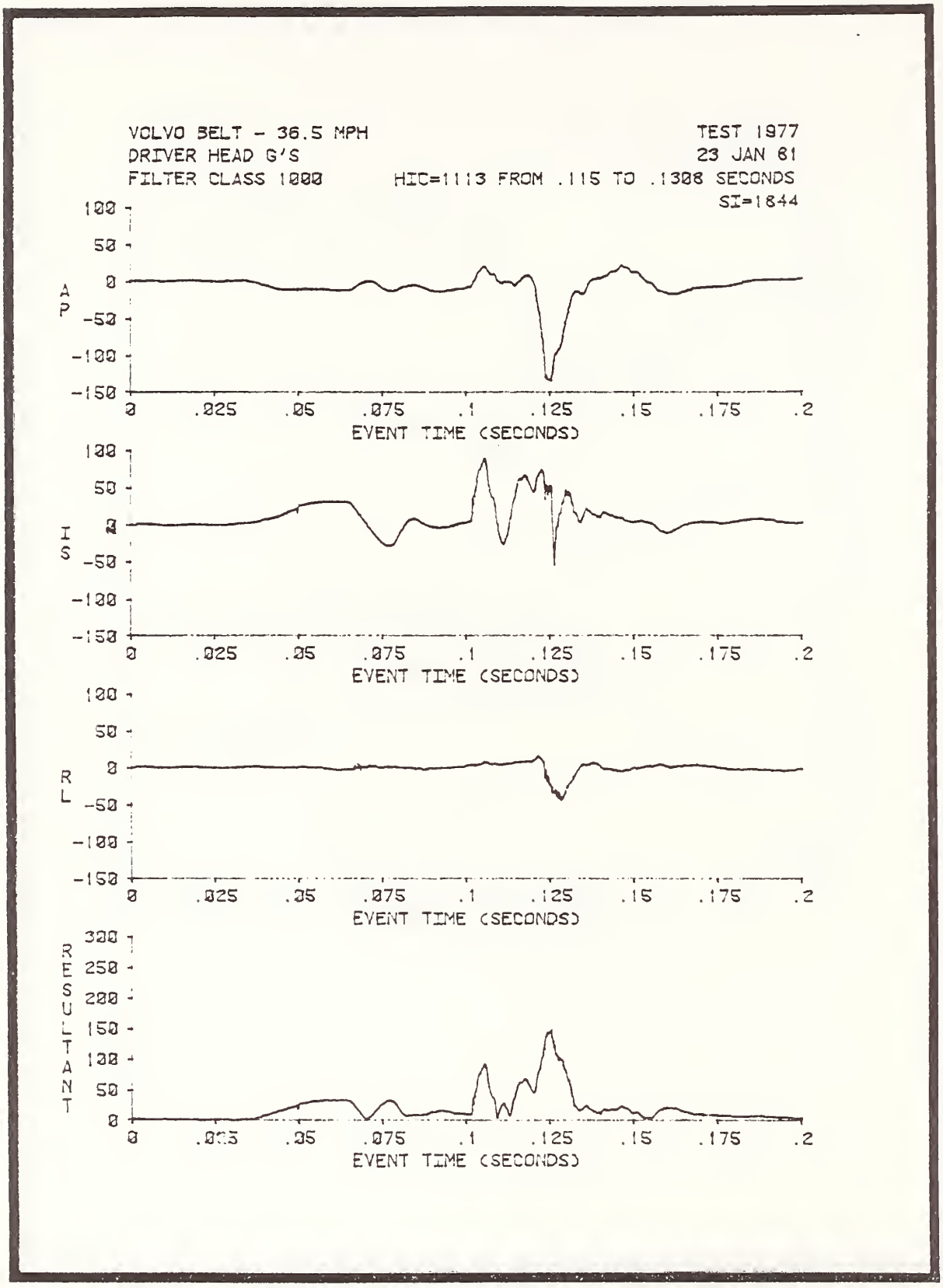
VOLVO BELT - 35.1 MPH

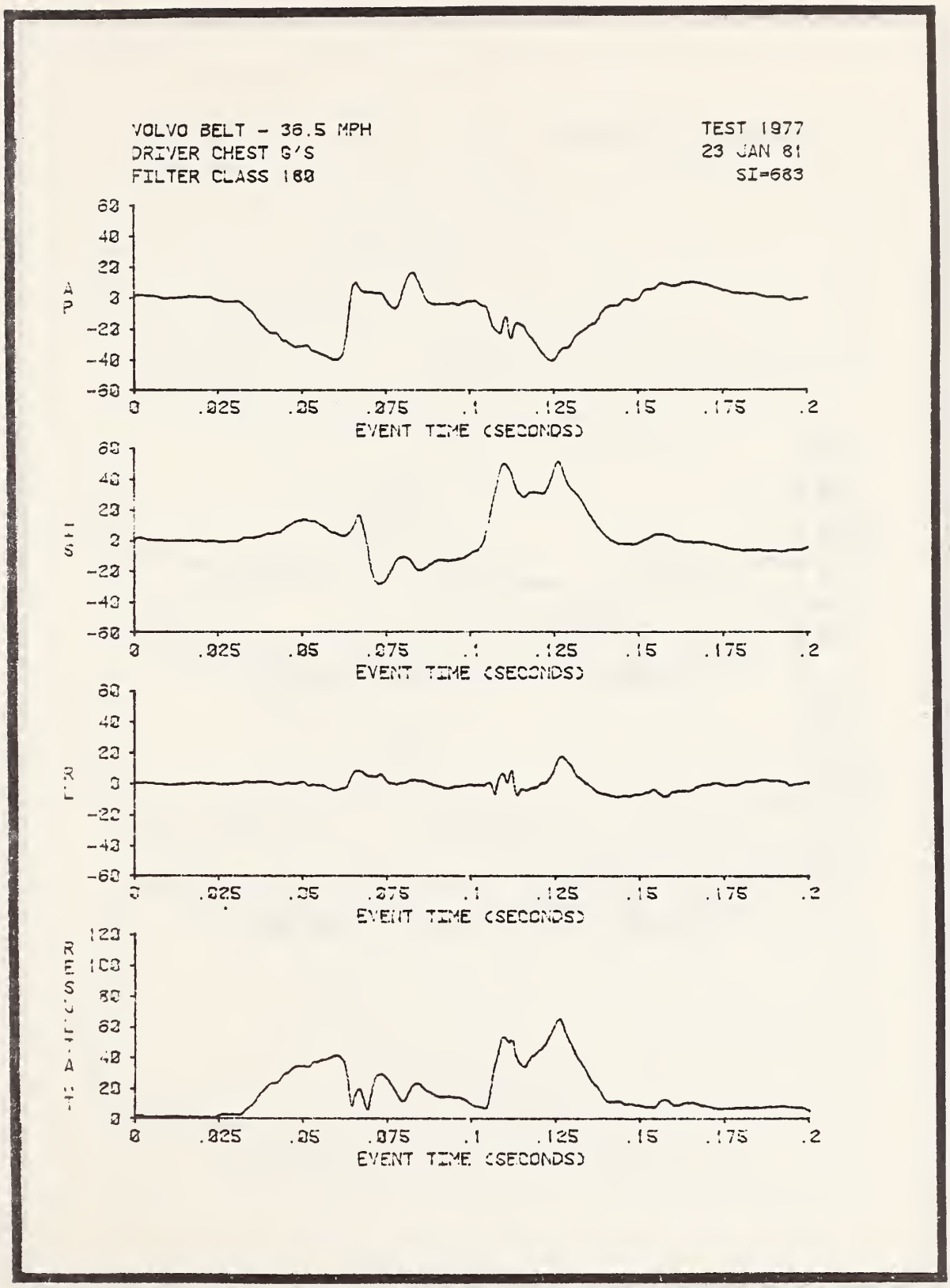
TEST 1974
20 JAN 81





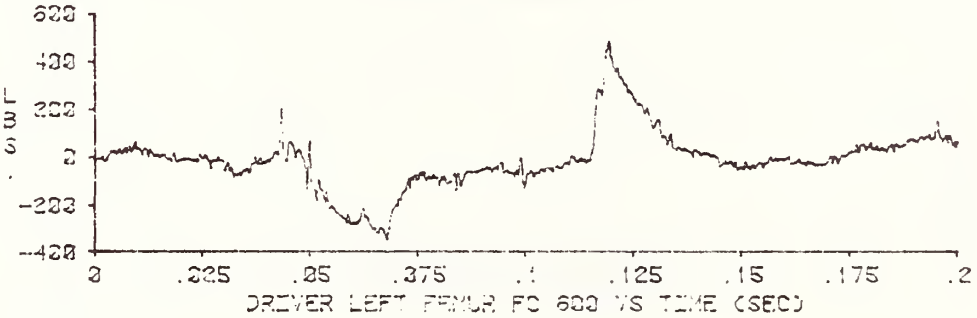

VOLVO BELT - 35.1 MPH
SLED AP
FILTER CLASS 180
TEST 1974
20 JAN 81
G'S
5
0
-5
-10
-15
-20
-25
-30
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
30
25
20
15
10
5
0
EVENT TIME (SECONDS)

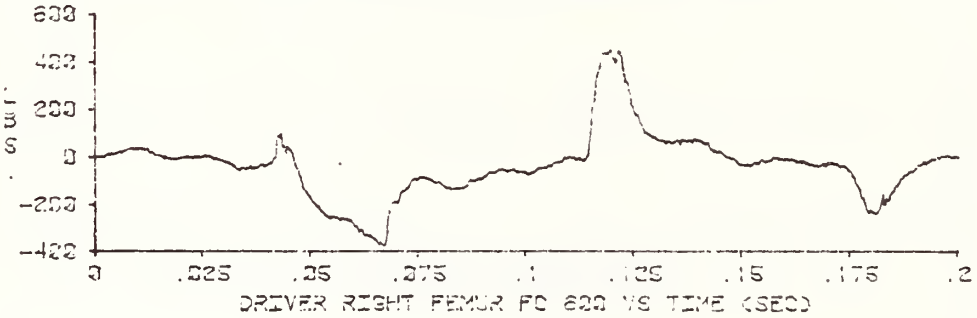

VOLVO BELT - 36.5 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=1113 FROM .115 TO .1308 SECONDS
SI=1844
TEST 1977
23 JAN 81
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

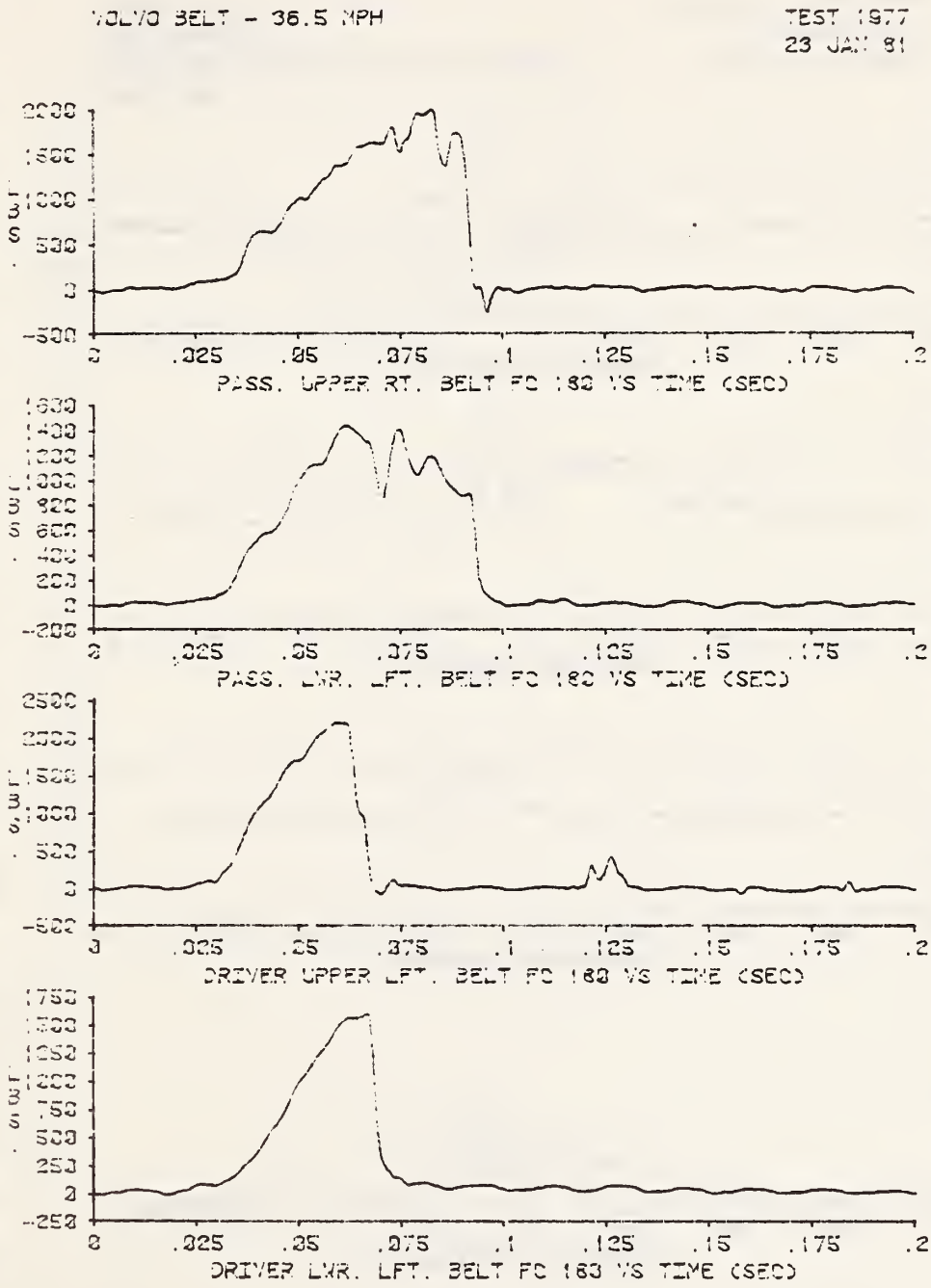

VOLVO BELT - 36.5 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1977
23 JAN 81
SI=683
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)
EVENT TIME (SECONDS)

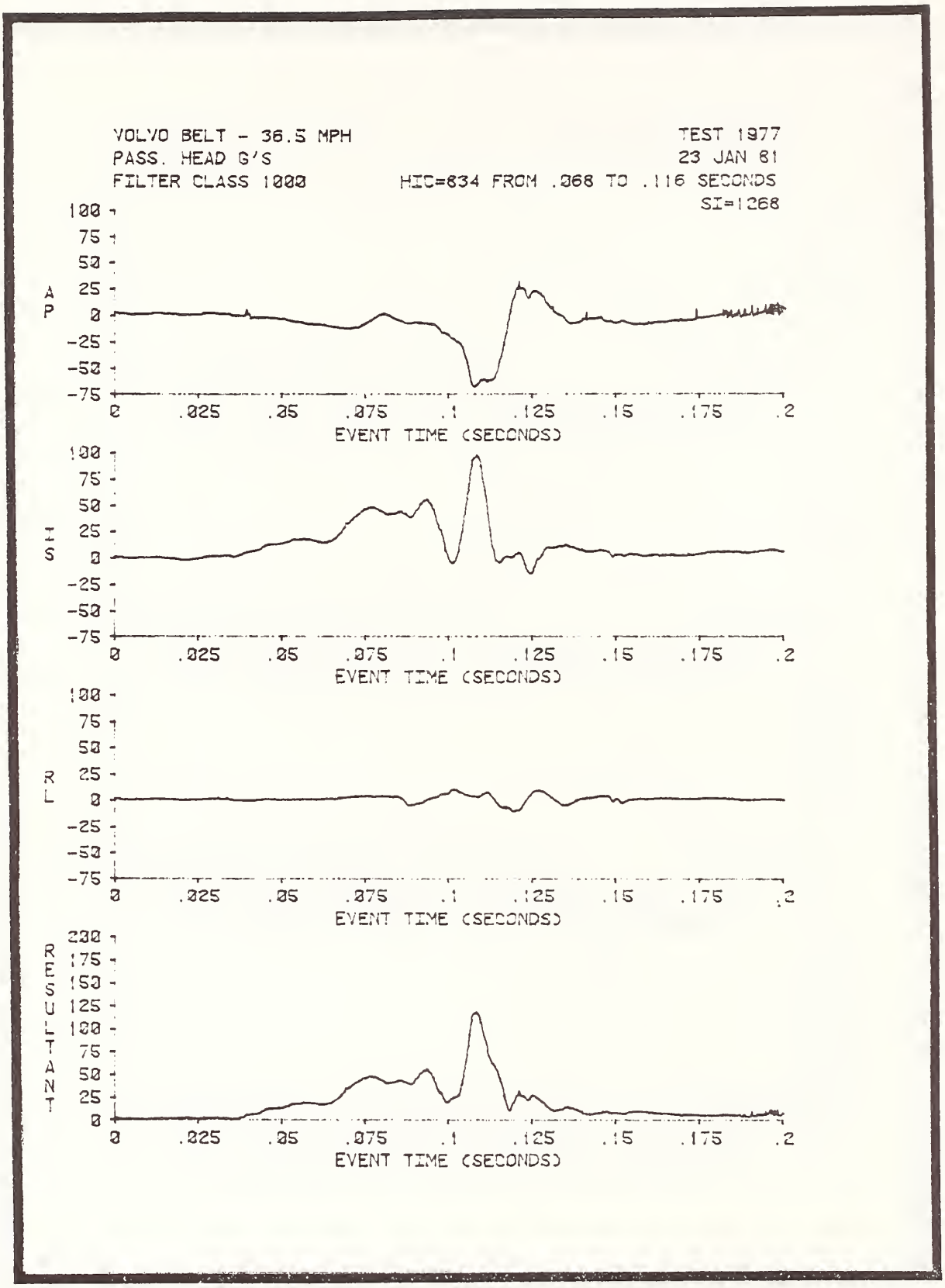
VOLVO BELT - 36.5 MPH

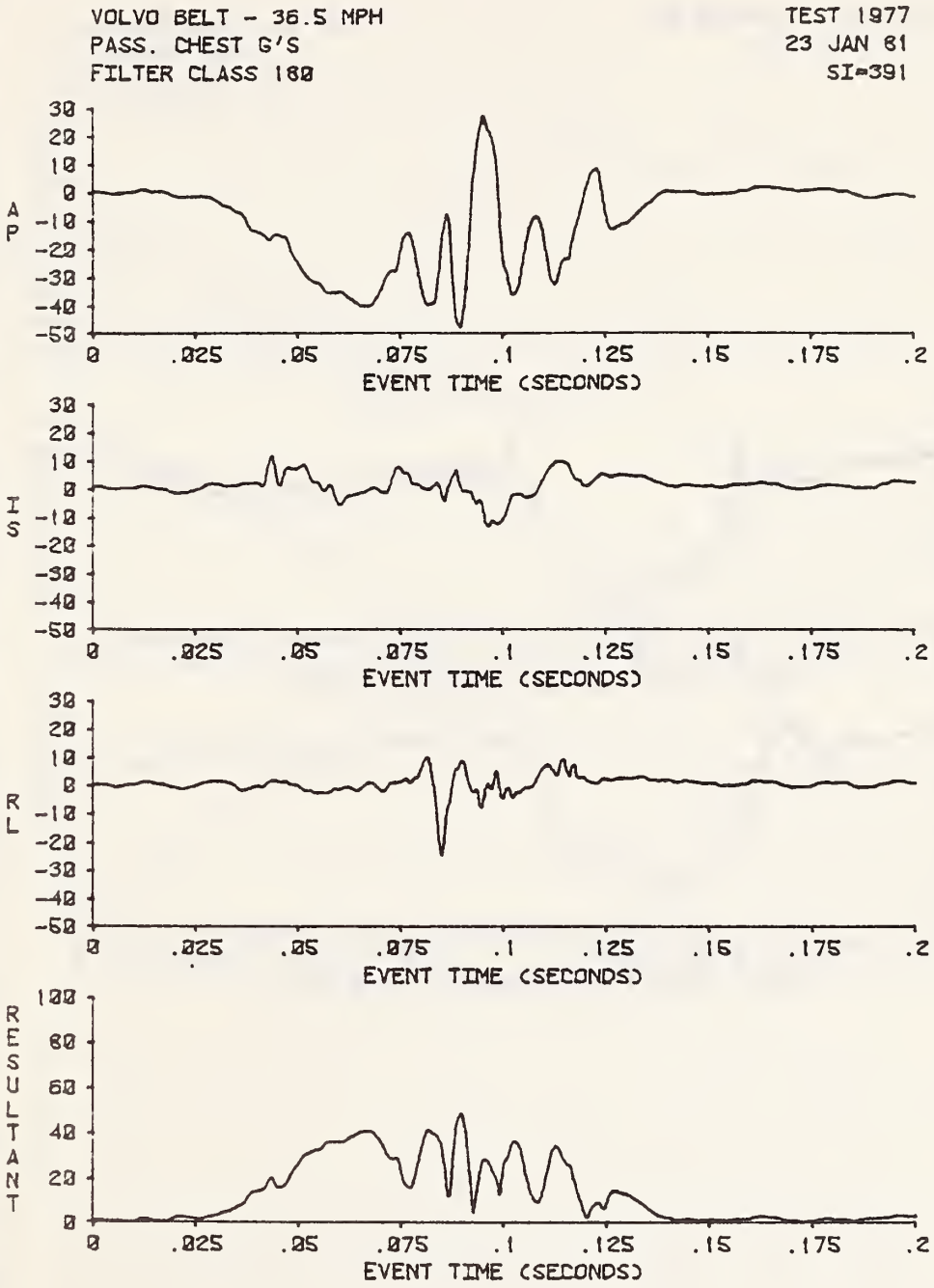
TEST 1977
23 JAN 81





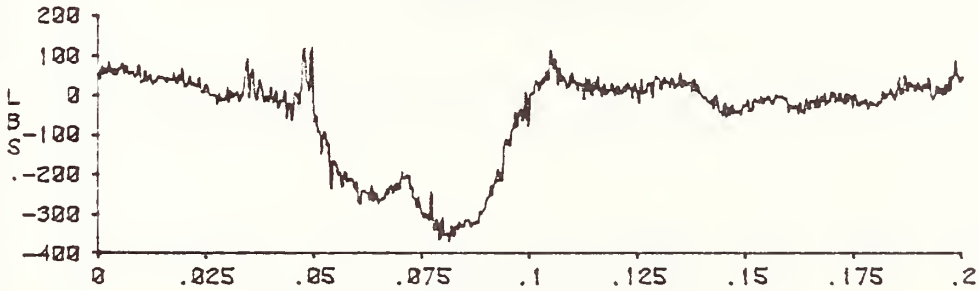

VOLVO BELT - 36.5 MPH
TEST 1977
23 JAN 81
PASS. UPPER RT. BELT FC 180 VS TIME (SEC)
PASS. LWR. LFT. BELT FC 180 VS TIME (SEC)
DRIVER UPPER LFT. BELT FC 180 VS TIME (SEC)
DRIVER LWR. LFT. BELT FC 180 VS TIME (SEC)


VOLVO BELT - 36.5 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=834 FROM .068 TO .116 SECONDS
TEST 1977
23 JAN 81
SI=1268
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)

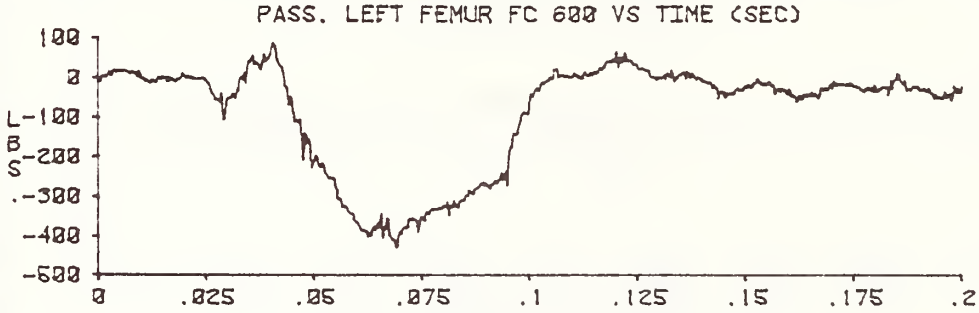

VOLVO BELT - 36.5 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1977
23 JAN 81
SI=391
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

VOLVO BELT - 36.5 MPH

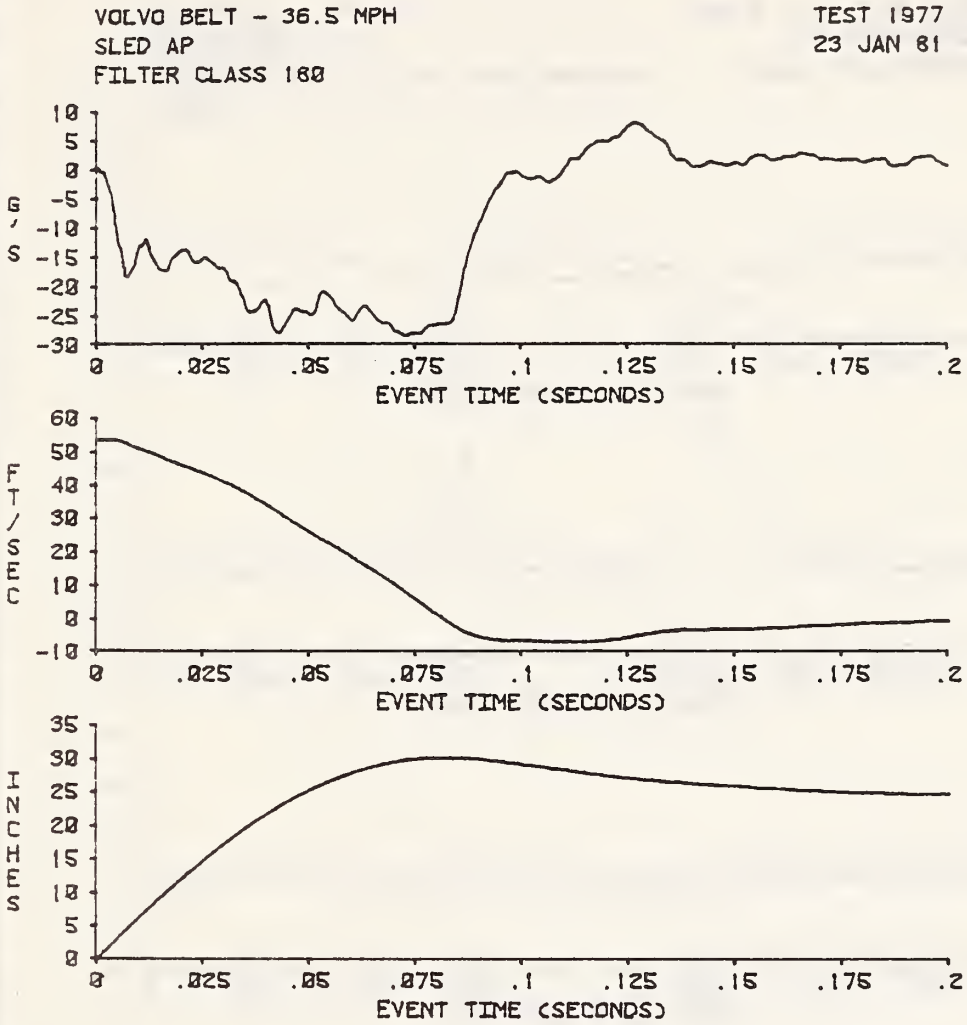
TEST 1977
23 JAN 81

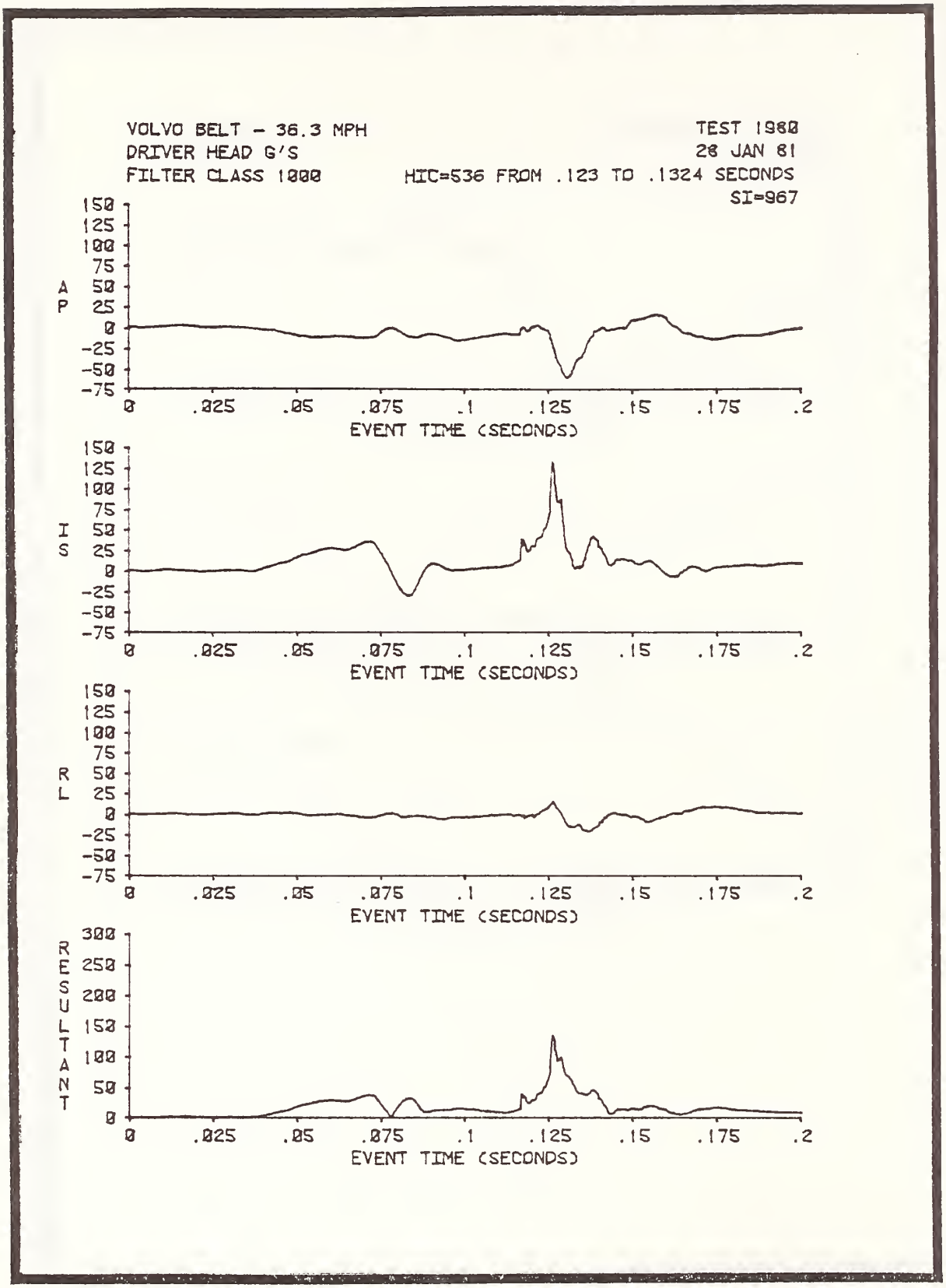


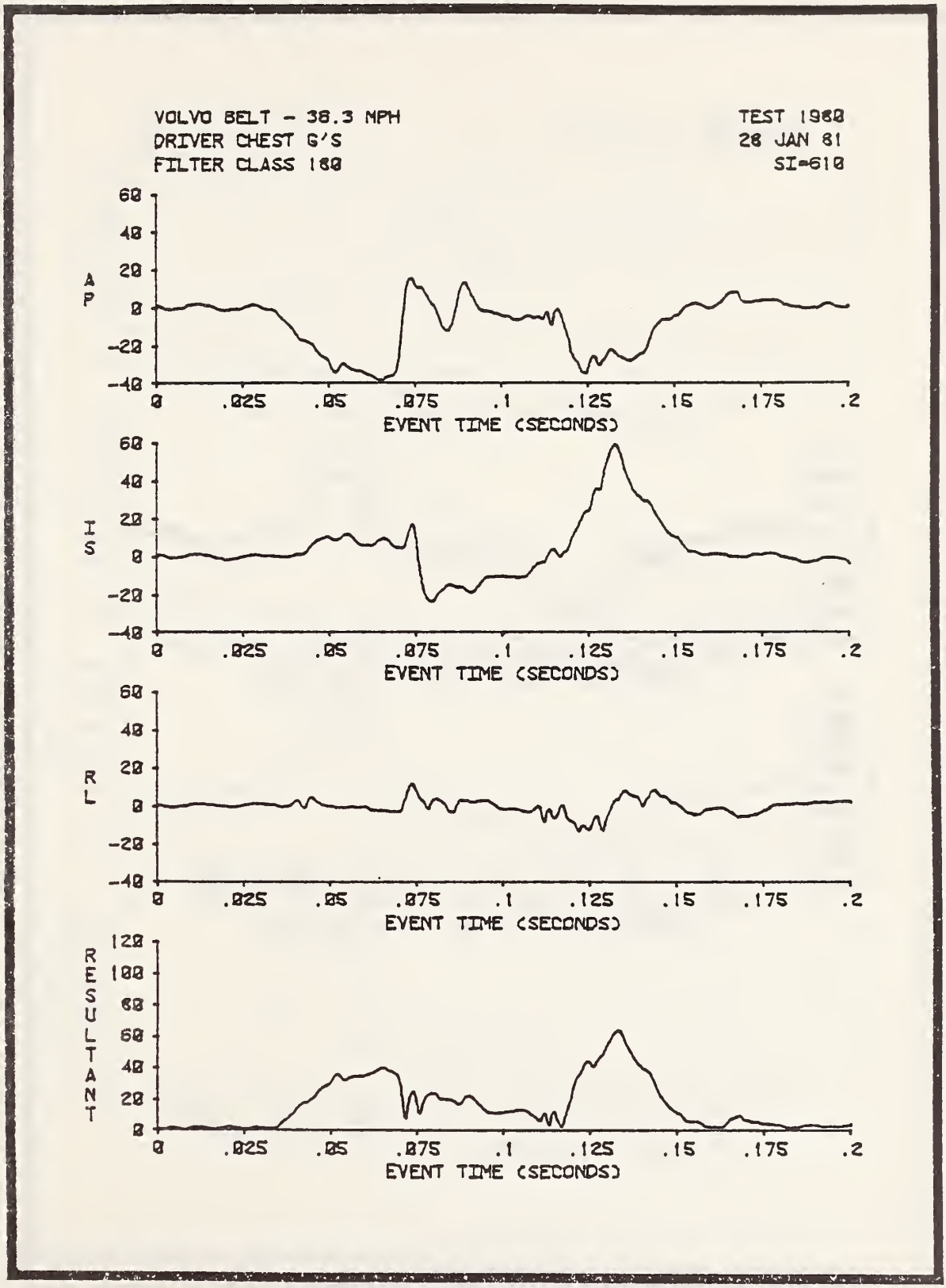
PASS. LEFT FEMUR FC 600 VS TIME (SEC)



PASS. RIGHT FEMUR FC 600 VS TIME (SEC)

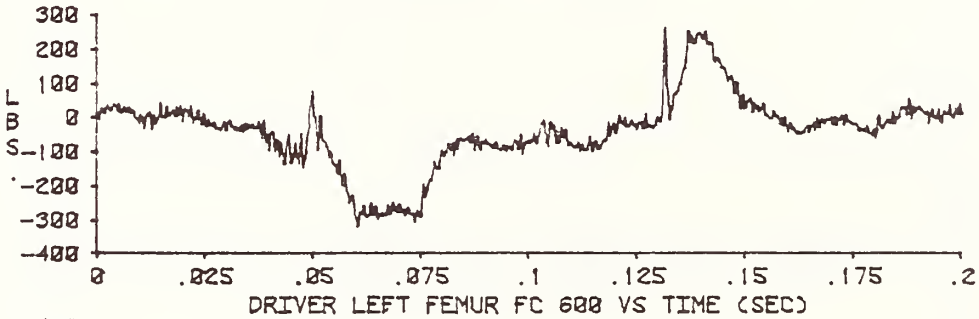

VOLVO BELT - 36.5 MPH
SLED AP
FILTER CLASS 180
TEST 1977
23 JAN 81
G'S
10
5
0
-5
-10
-15
-20
-25
-30
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)

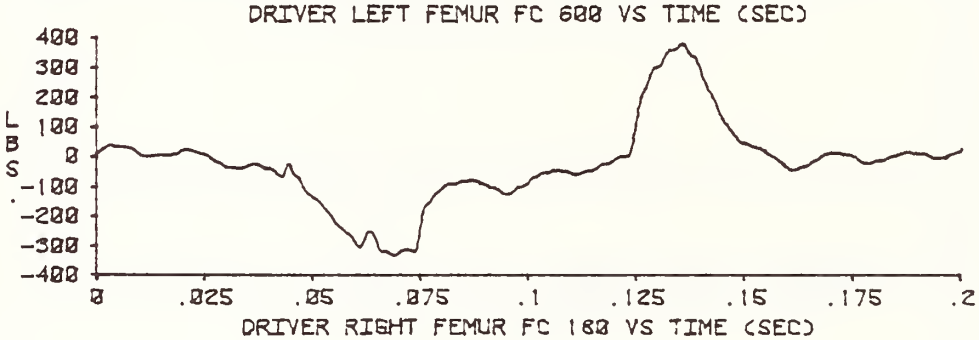

VOLVO BELT - 36.3 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=536 FROM .123 TO .1324 SECONDS
SI=967
TEST 1960
26 JAN 81
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

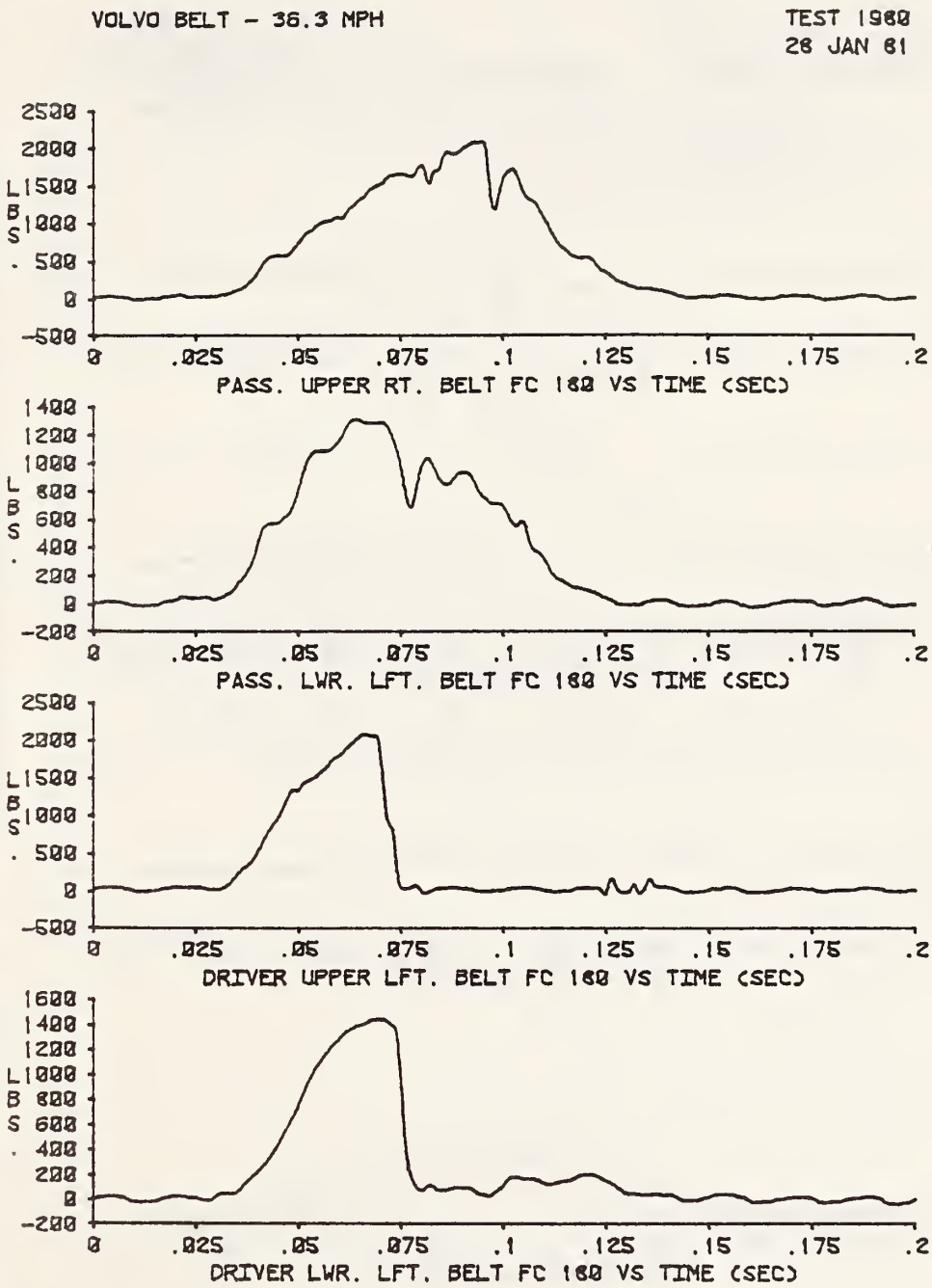

VOLVO BELT - 38.3 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1960
28 JAN 81
SI=610
AP
IS
RL
RESULTANT
60
40
20
0
-20
-40
120
100
80
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

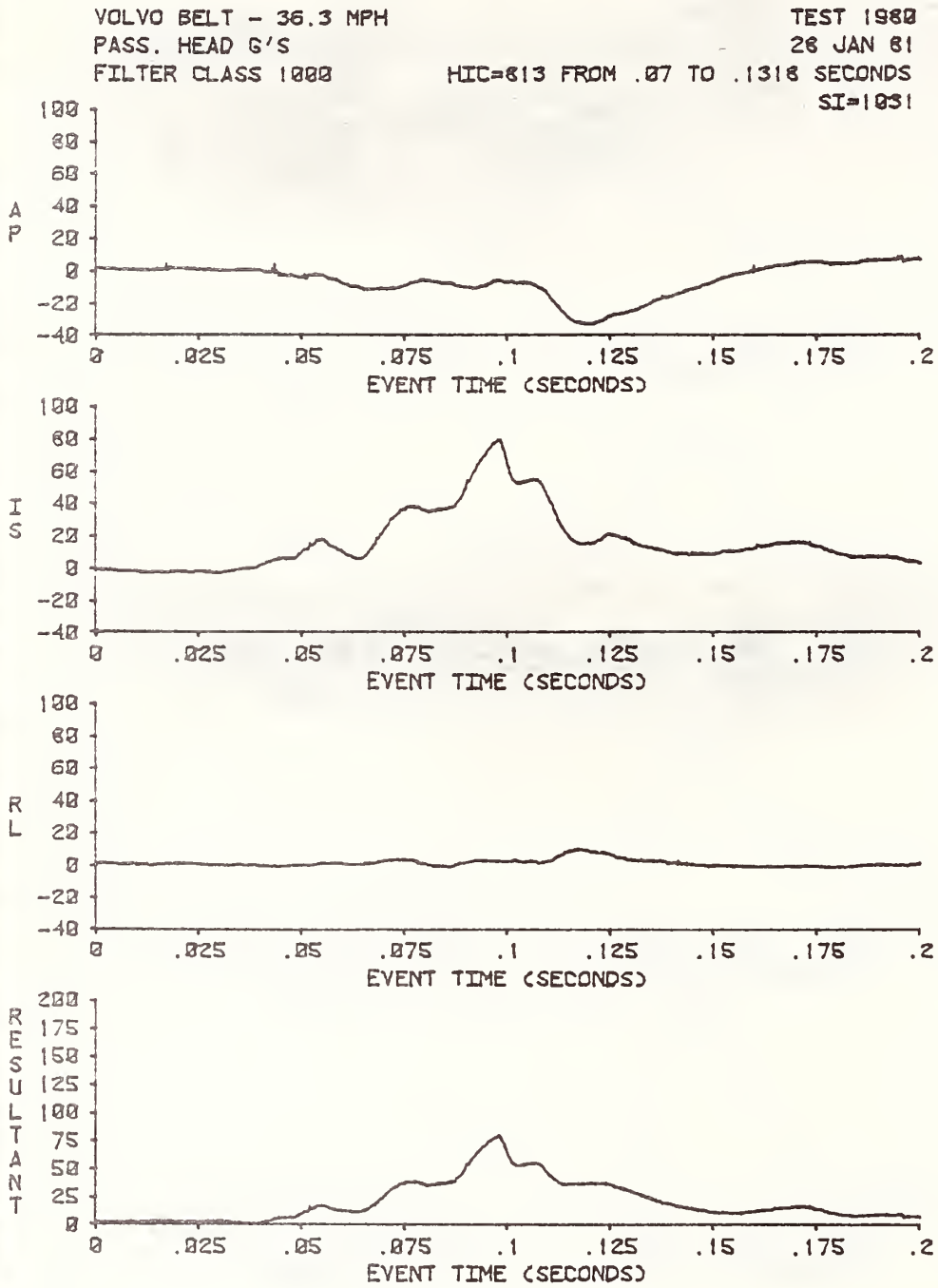
VOLVO BELT - 36.3 MPH

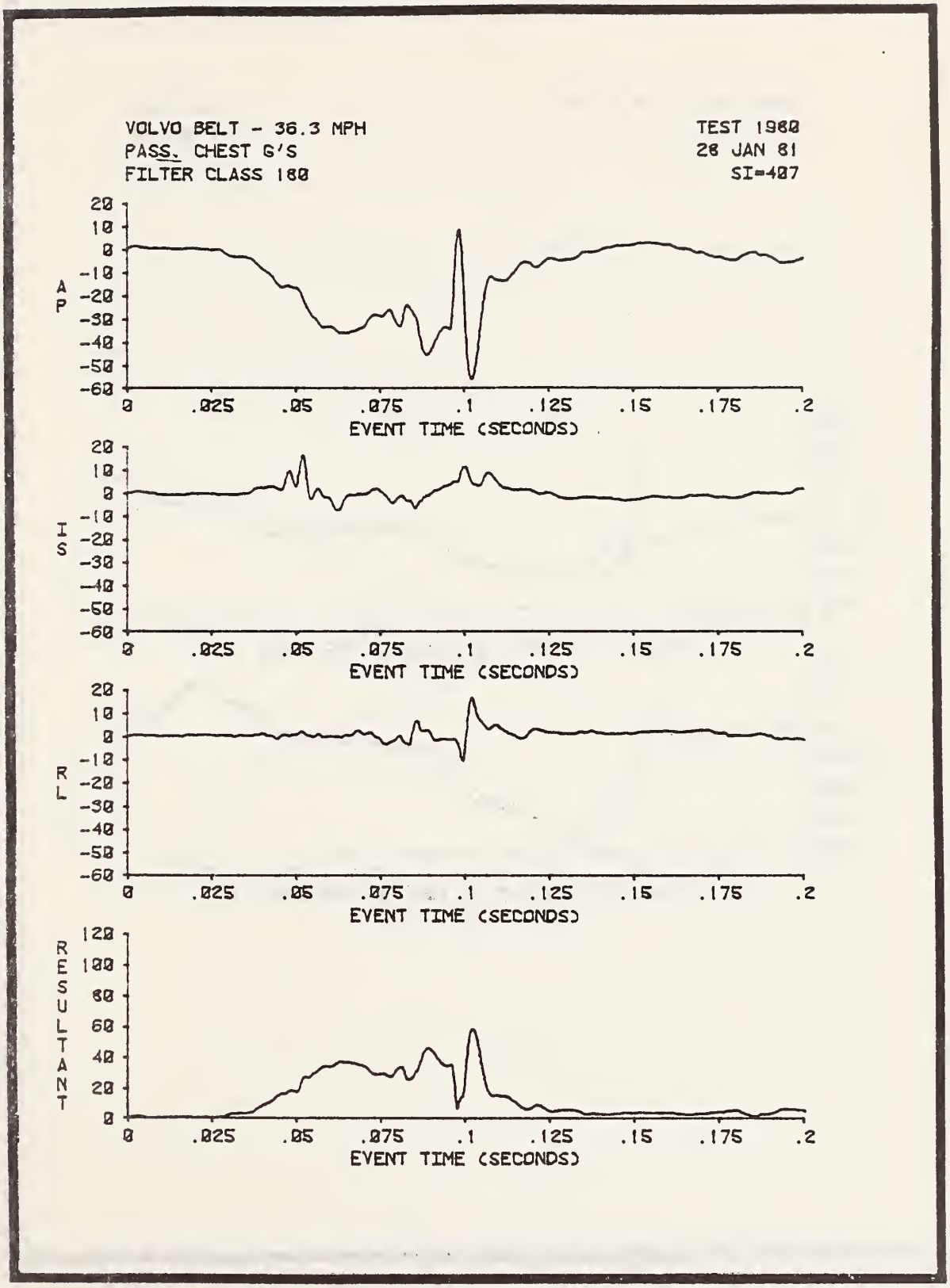
TEST 1960
28 JAN 81





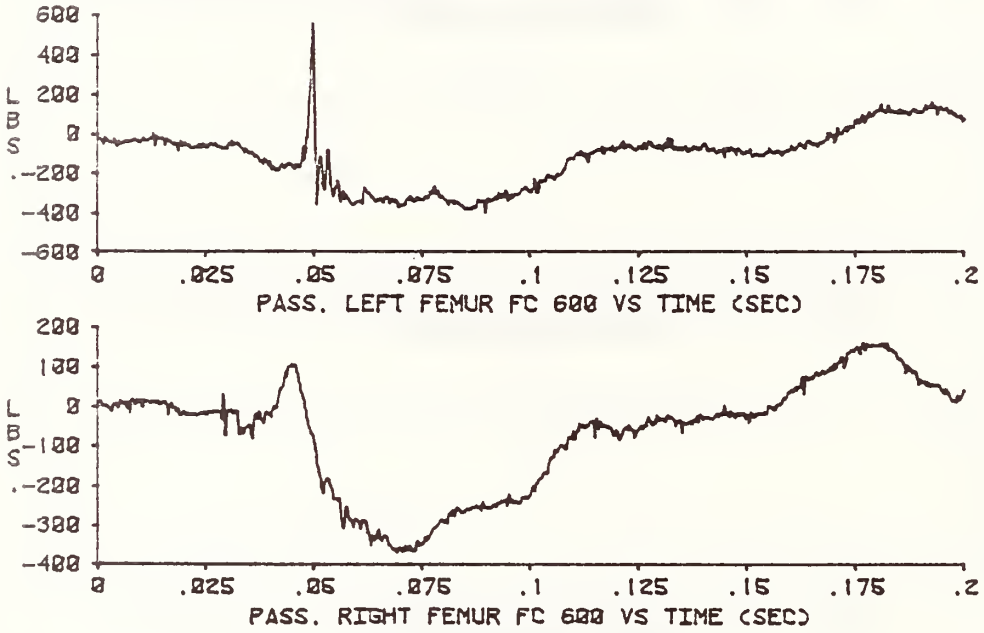

VOLVO BELT - 36.3 MPH
TEST 1960
26 JAN 81
LBS
PASS. UPPER RT. BELT FC 160 VS TIME (SEC)
PASS. LWR. LFT. BELT FC 160 VS TIME (SEC)
DRIVER UPPER LFT. BELT FC 160 VS TIME (SEC)
DRIVER LWR. LFT. BELT FC 160 VS TIME (SEC)

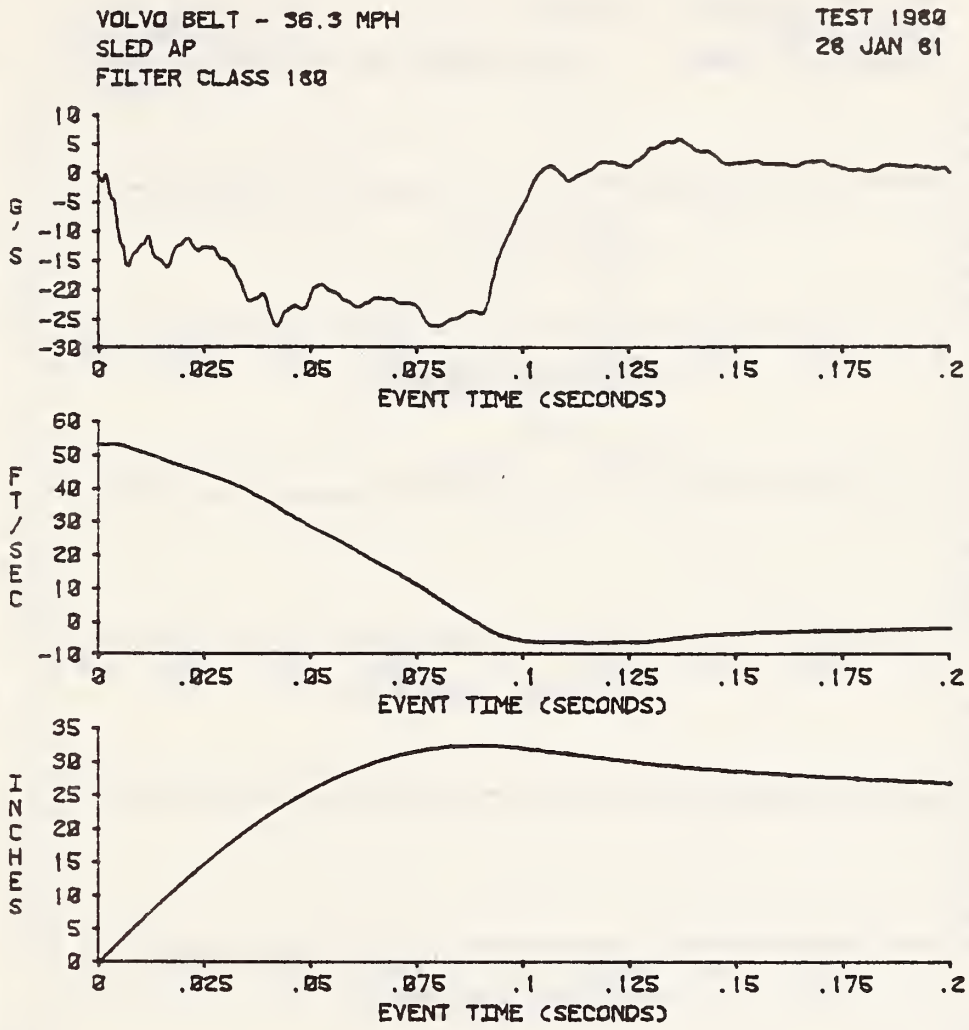

VOLVO BELT - 36.3 MPH
PASS. HEAD G'S
FILTER CLASS 1000
HIC=613 FROM .07 TO .1316 SECONDS
SI=1031
TEST 1980
26 JAN 81
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

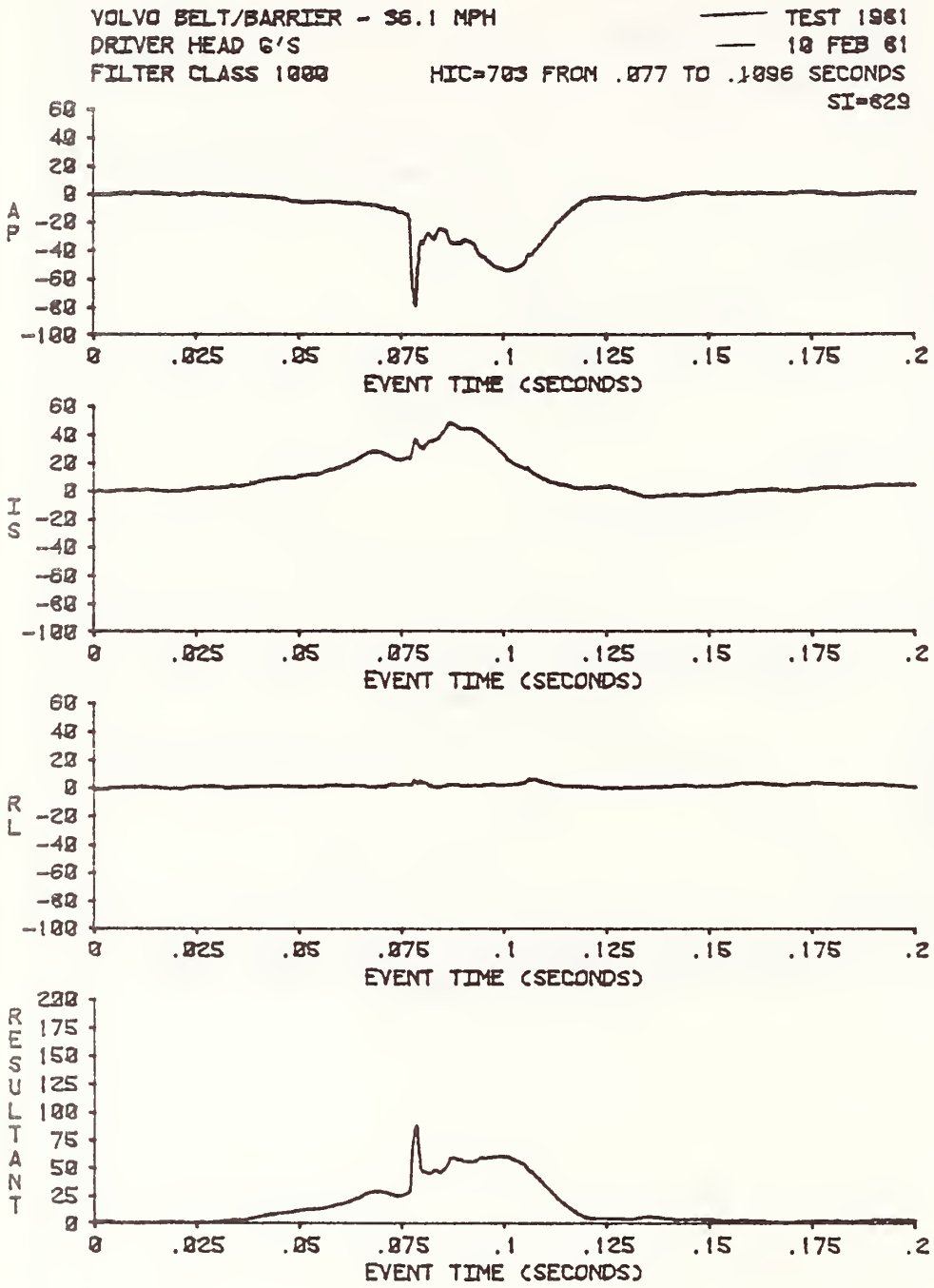

VOLVO BELT - 36.3 MPH
PASS. CHEST G'S
FILTER CLASS 180
TEST 1960
28 JAN 81
SI=407
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

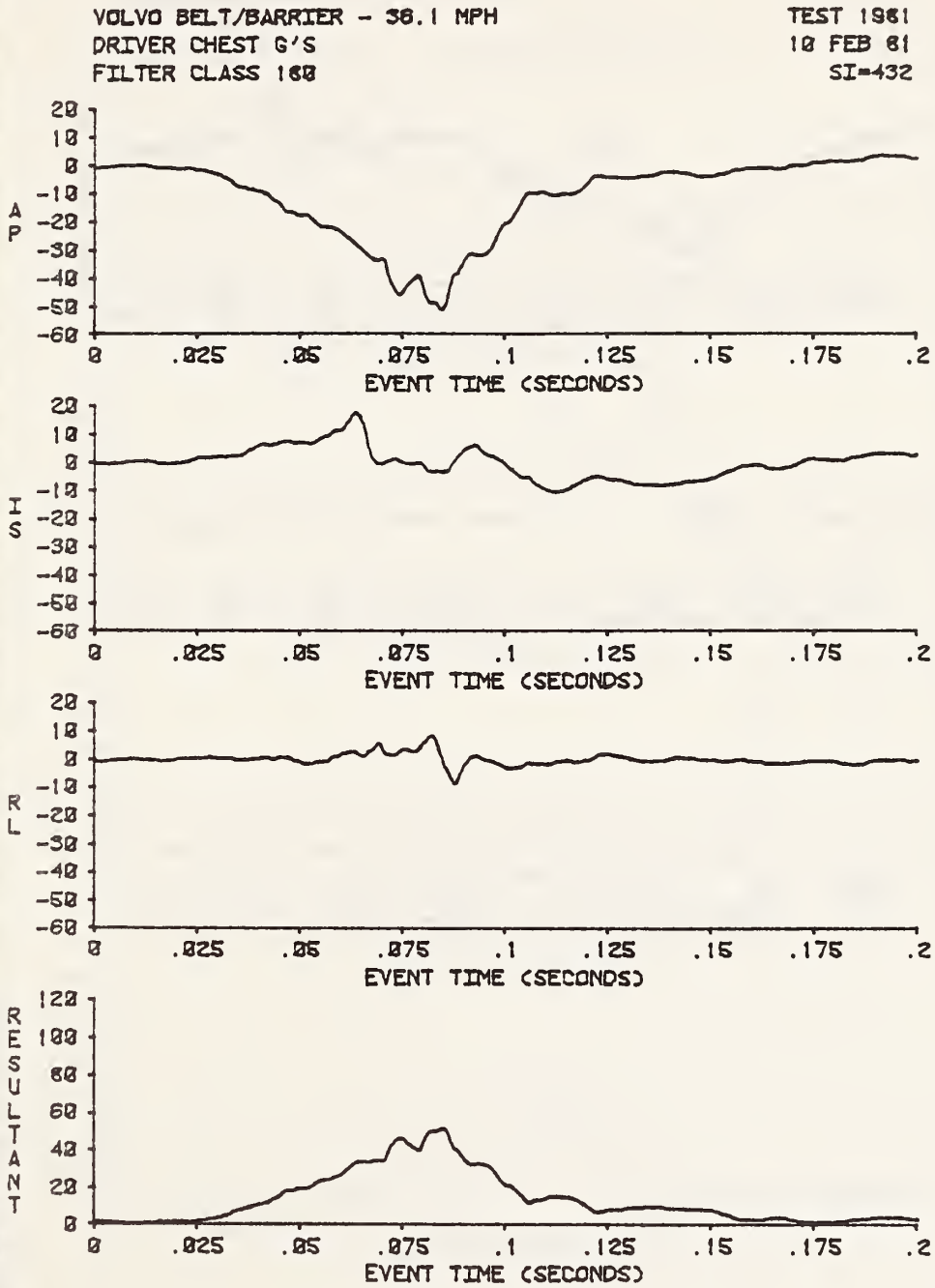
VOLVO BELT - 36.3 MPH

TEST 1980
26 JAN 81



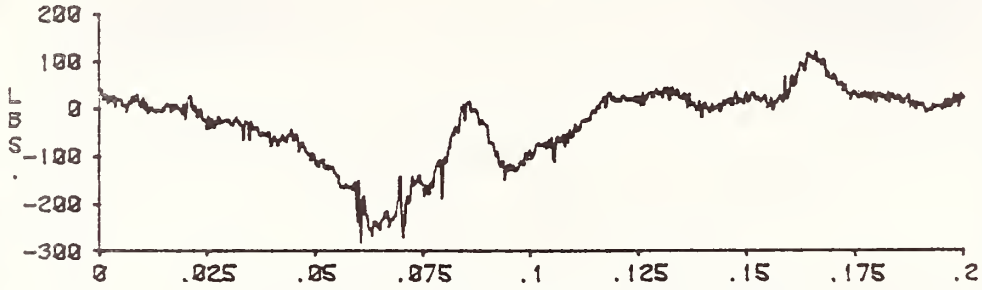

VOLVO BELT - 36.3 MPH
SLED AP
FILTER CLASS 180
TEST 1980
28 JAN 81
G'S
10
5
0
-5
-10
-15
-20
-25
-30
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)


VOLVO BELT/BARRIER - 36.1 MPH
DRIVER HEAD G'S
FILTER CLASS 1000
HIC=703 FROM .077 TO .1096 SECONDS
SI=629
TEST 1961
10 FEB 61
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

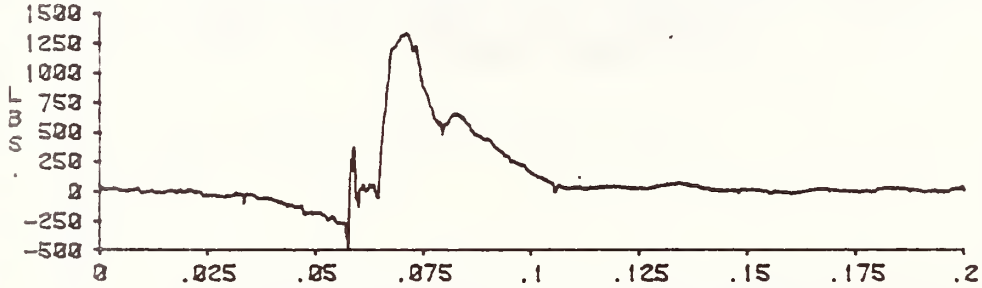

VOLVO BELT/BARRIER - 38.1 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1981
10 FEB 81
SI=432
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

VOLVO BELT/BARRIER - 36.1 MPH

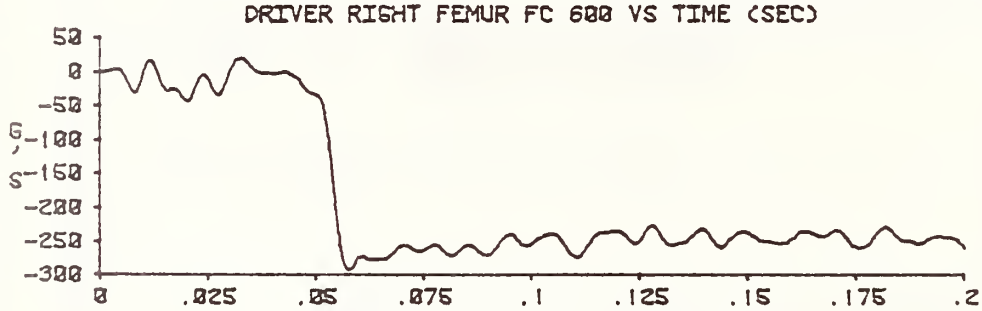
TEST 1961
10 FEB 81



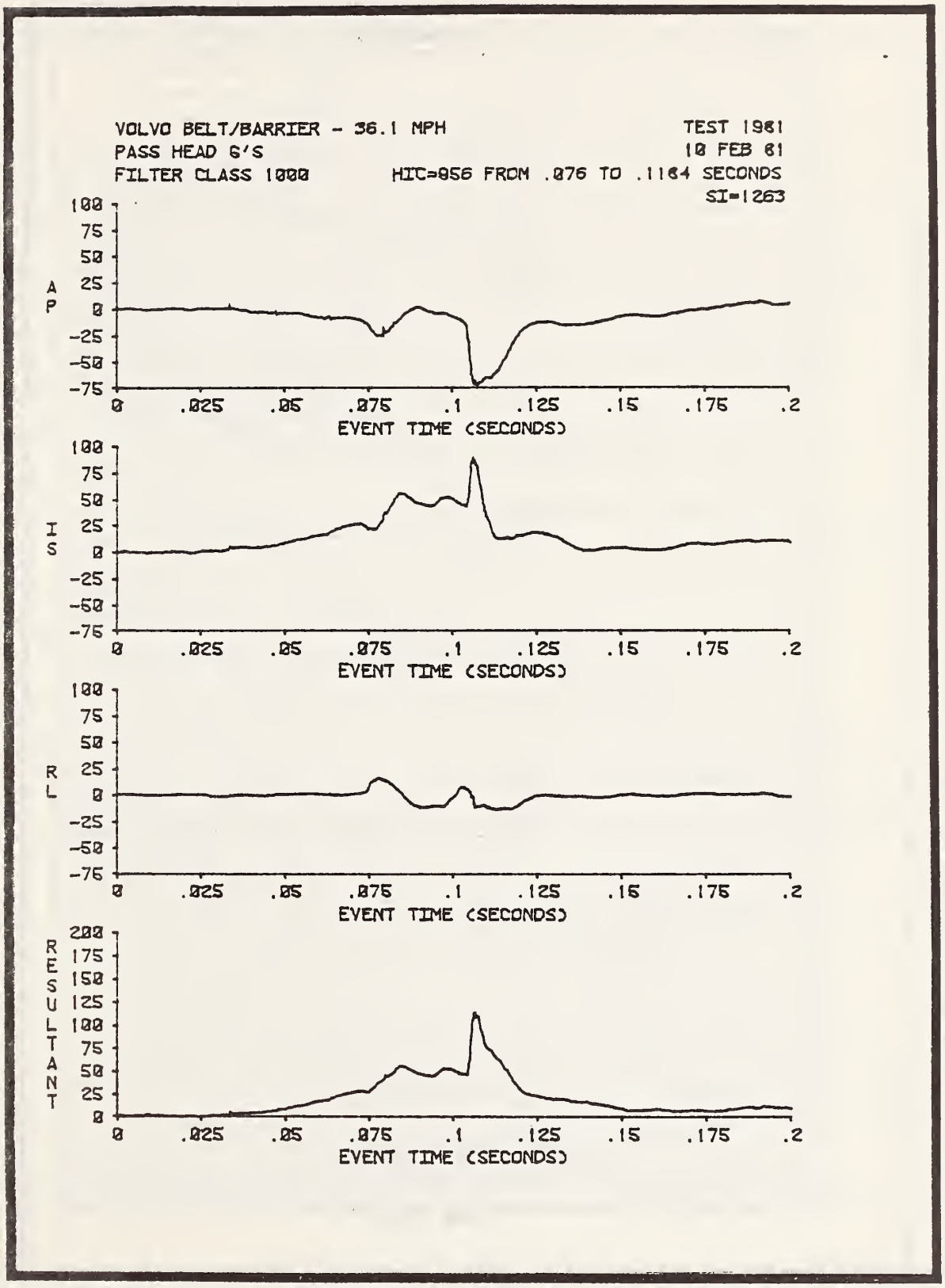
DRIVER LEFT FEMUR FC 600 VS TIME (SEC)

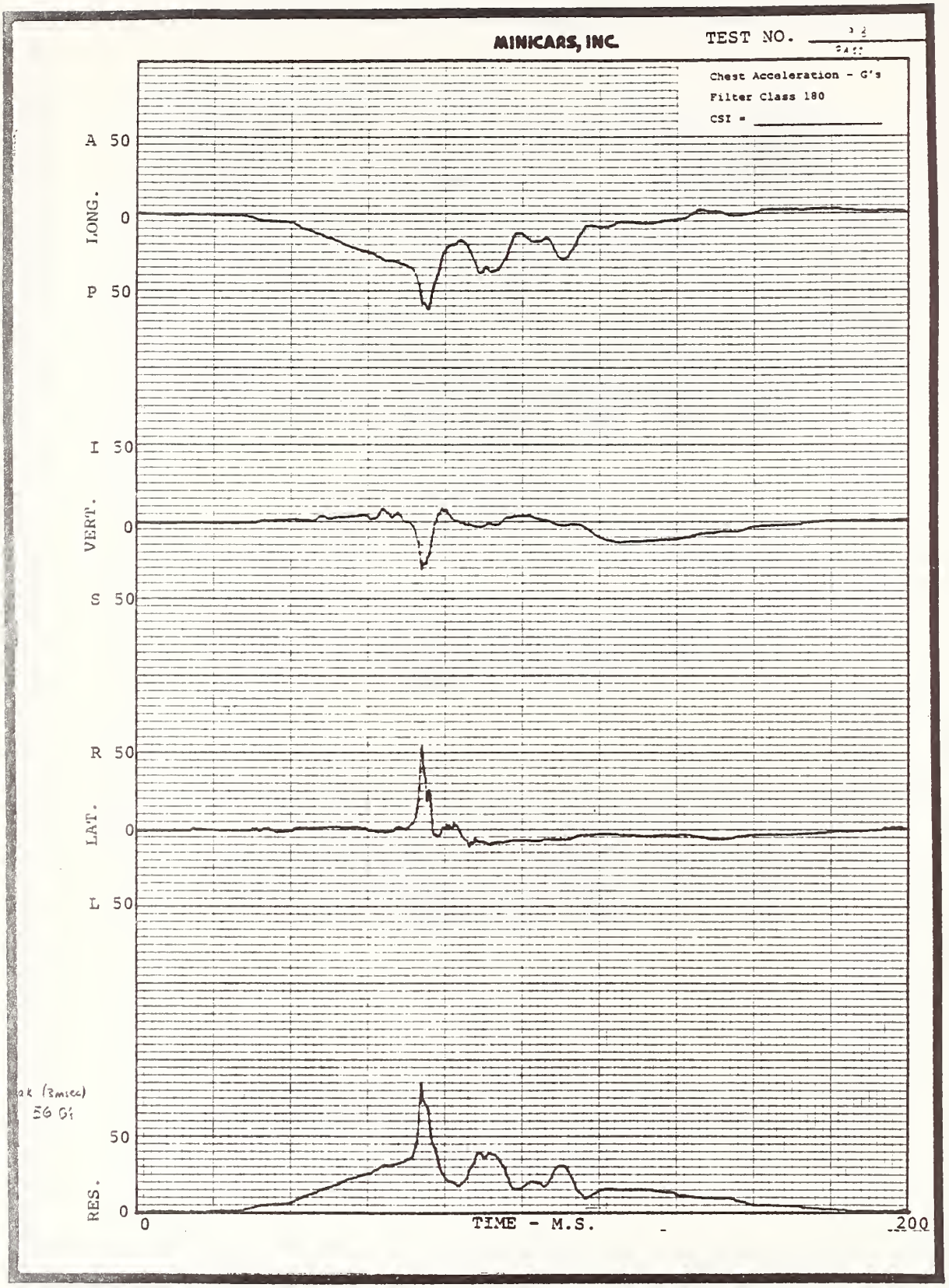


DRIVER RIGHT FEMUR FC 600 VS TIME (SEC)



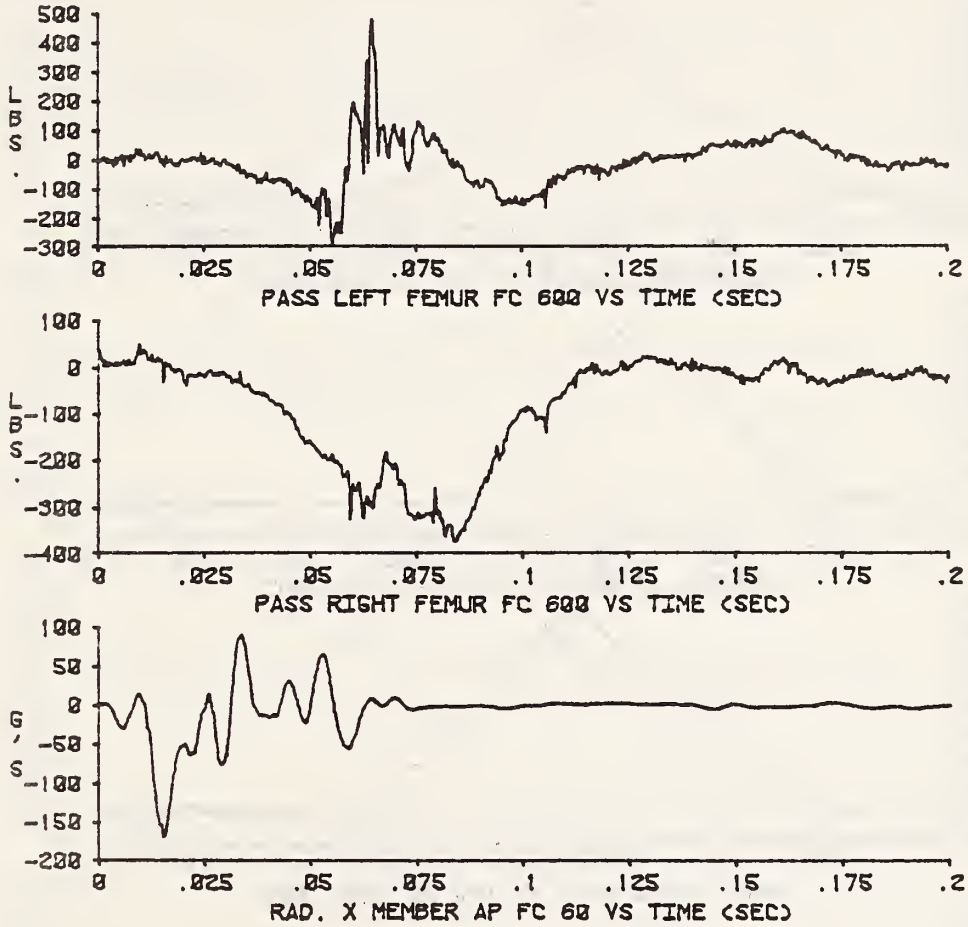
FIREWALL AP FC 60 VS TIME (SEC)


VOLVO BELT/BARRIER - 36.1 MPH
TEST 1961
PASS HEAD G'S
10 FEB 81
FILTER CLASS 1000
HIC=956 FROM .076 TO .1164 SECONDS
SI=1263
AP
IS
RL
RESULTANT
100
75
50
25
0
-25
-50
-75
200
175
150
125
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)


MINICARS, INC.
TEST NO.
Chest Acceleration - G's
Filter Class 180
CSI =
A 50
LONG.
0
P 50
I 50
VERT.
0
S 50
R 50
LAT.
0
L 50
50
RES.
0
0
TIME - M.S.
200

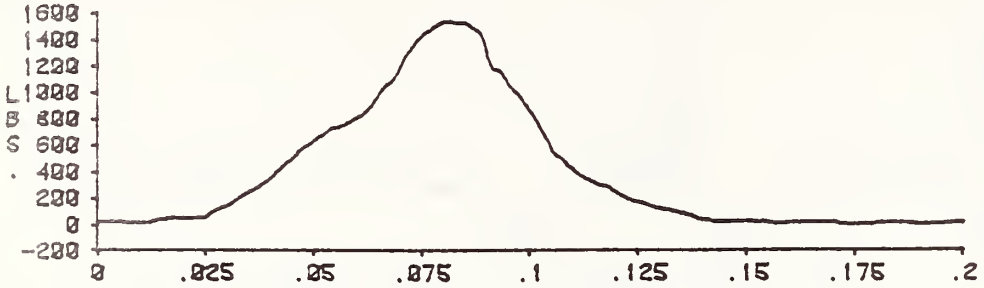
VOLVO BELT/BARRIER - 36.1 MPH

TEST 1961
10 FEB 81

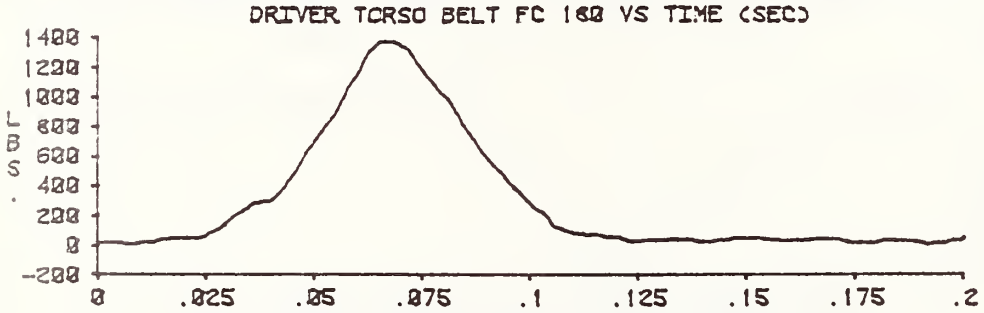


VOLVO BELT/BARRIER - 36.1 MPH

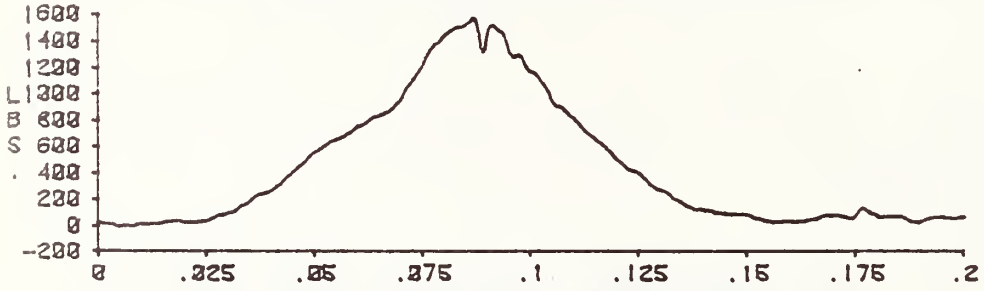
TEST 1961
10 FEB 81



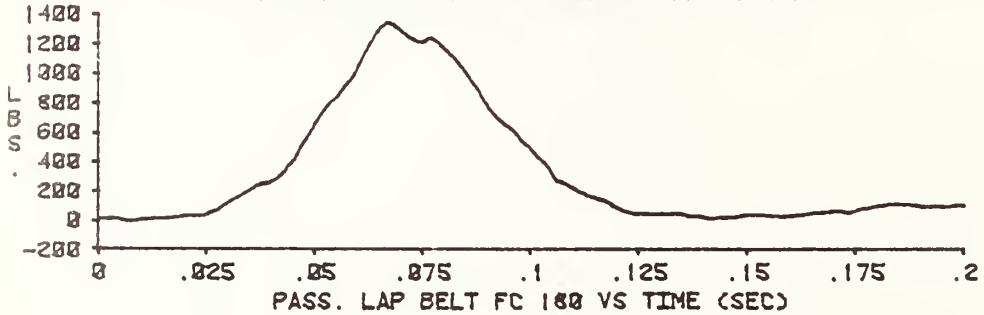
DRIVER TORSO BELT FC 160 VS TIME (SEC)



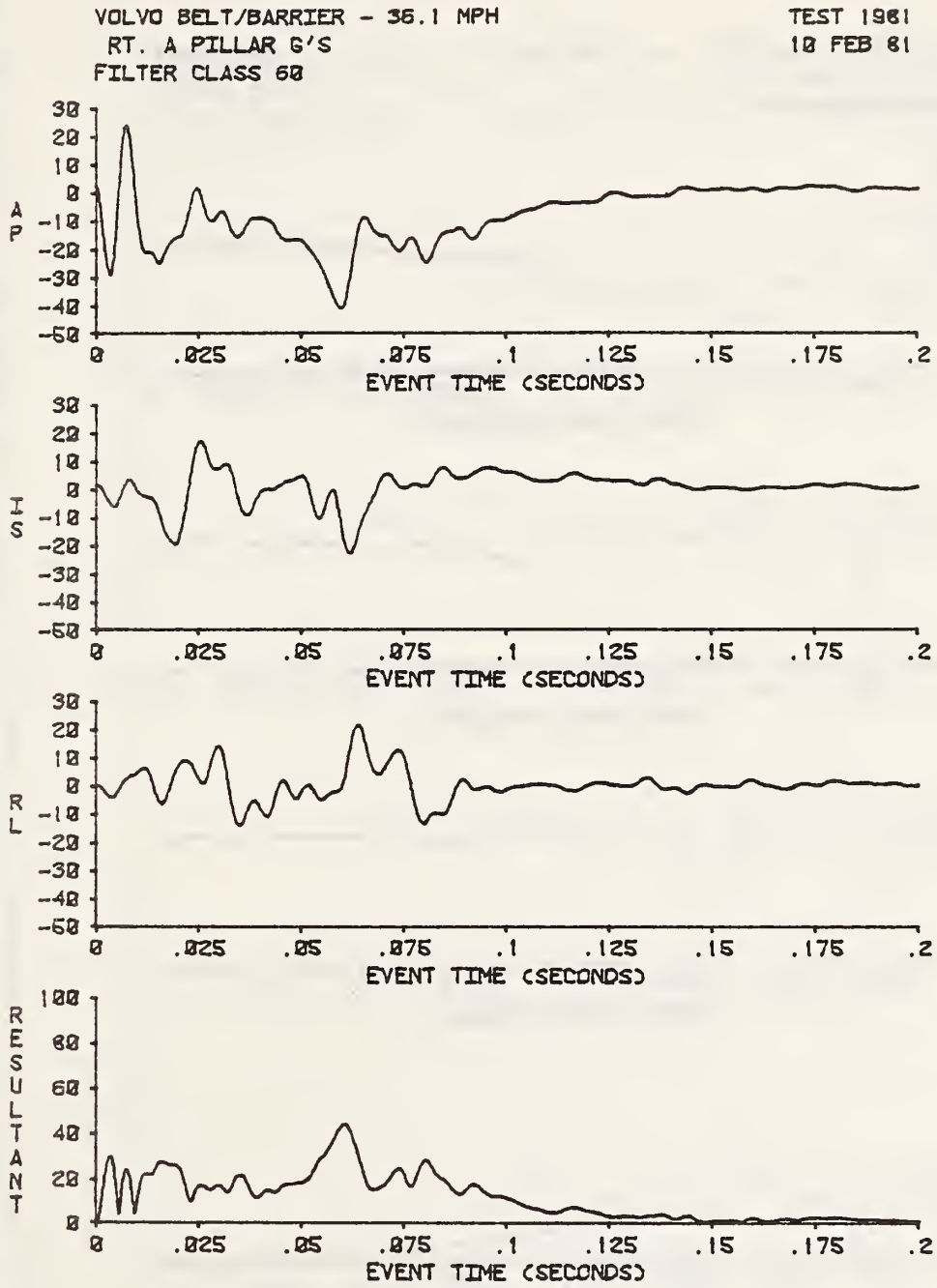
DRIVER LAP BELT FC 160 VS TIME (SEC)

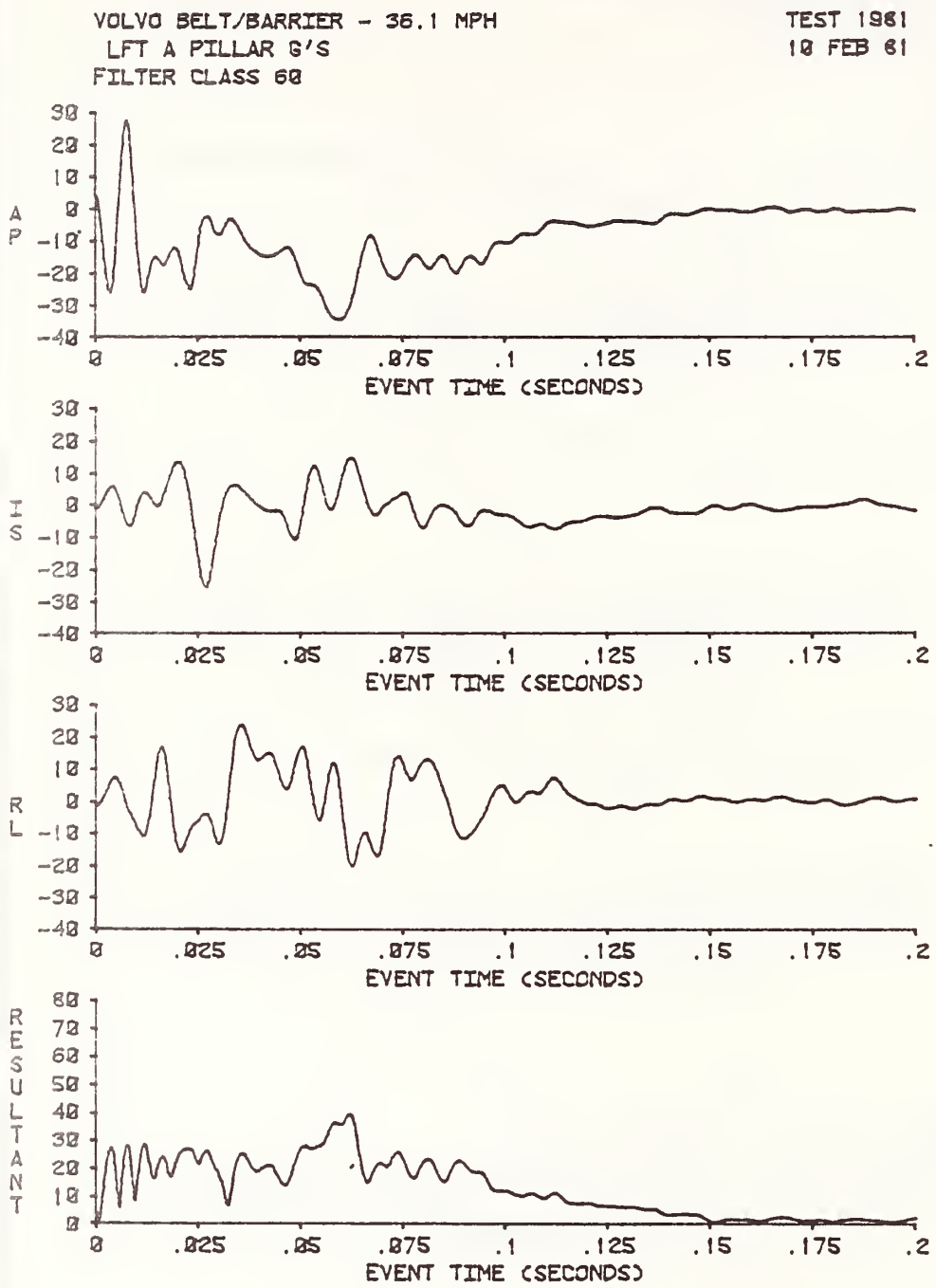


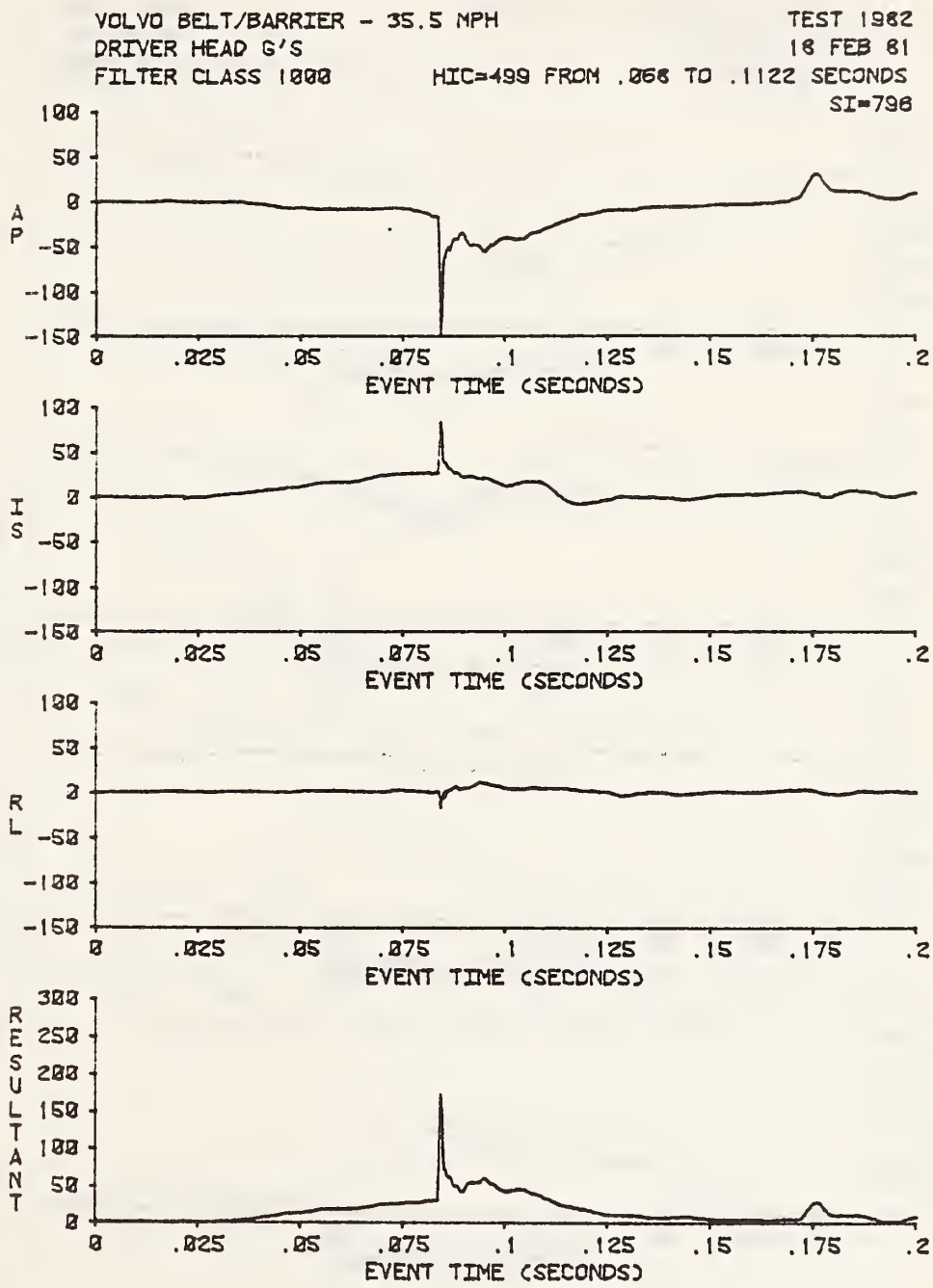
PASS. TORSO BELT FC 160 VS TIME (SEC)

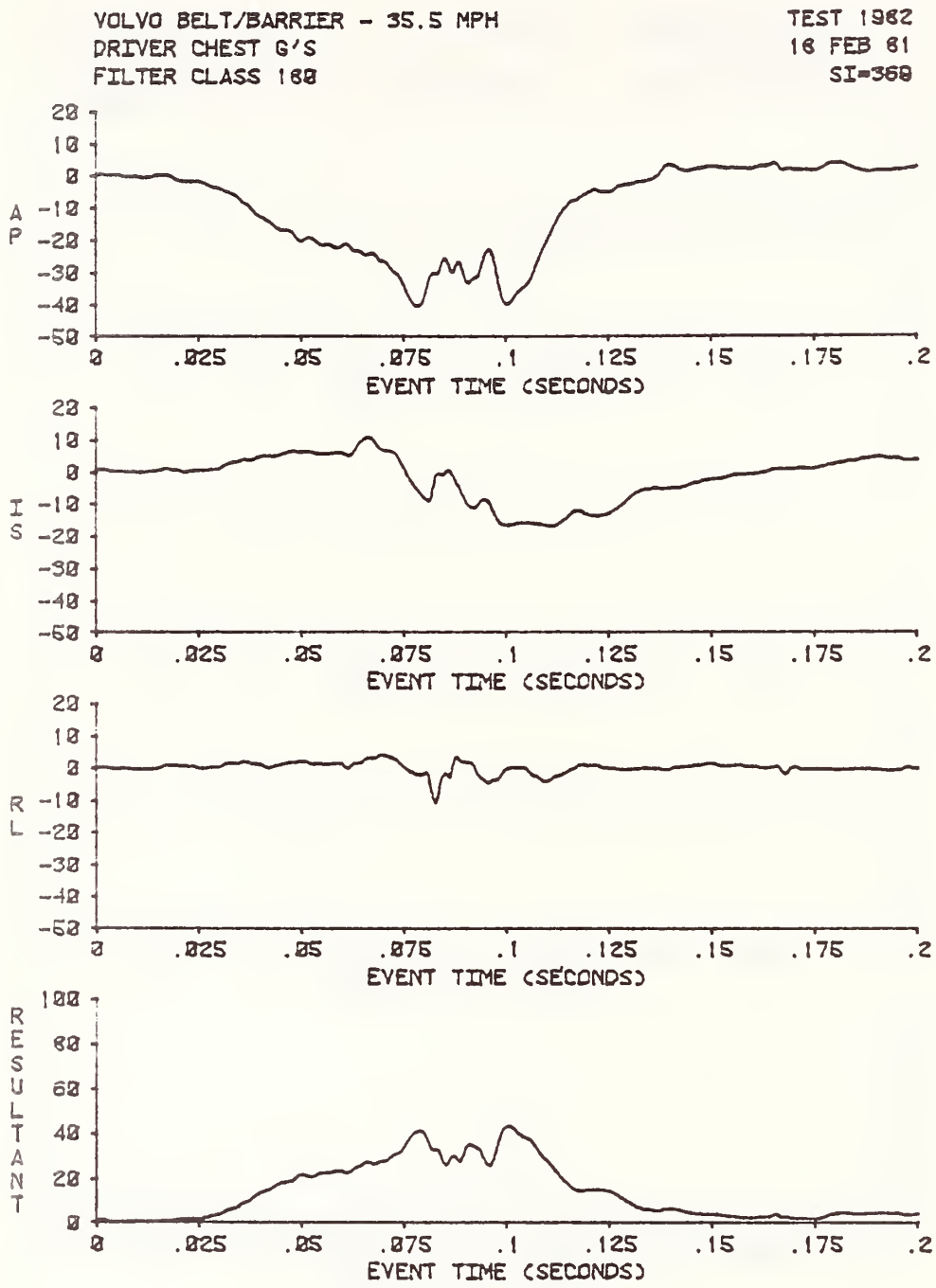


PASS. LAP BELT FC 160 VS TIME (SEC)


VOLVO BELT/BARRIER - 36.1 MPH
RT. A PILLAR G'S
FILTER CLASS 60
TEST 1961
10 FEB 81
AP
IS
RL
RESULTANT
30
20
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

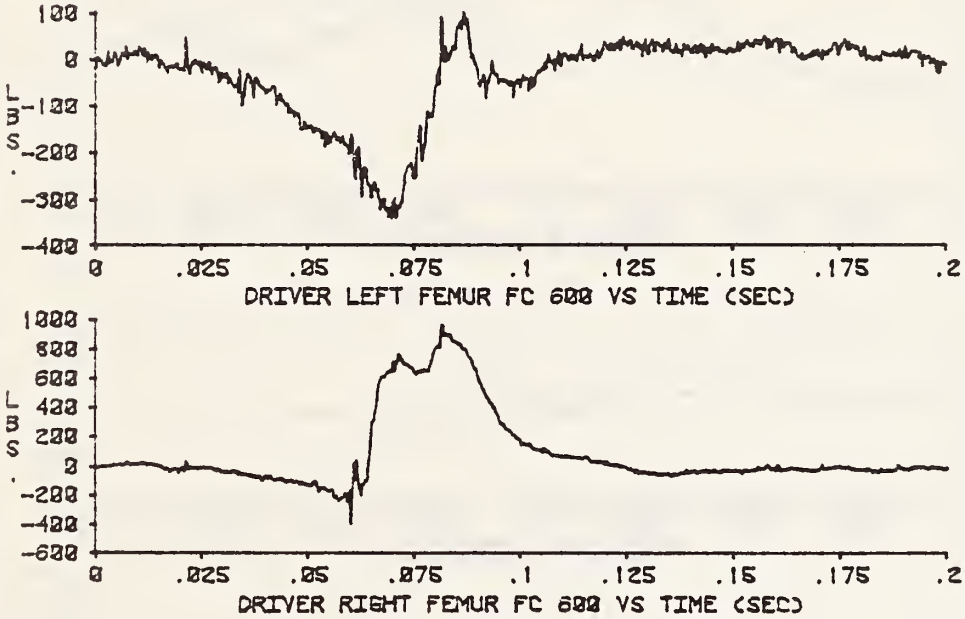

VOLVO BELT/BARRIER - 36.1 MPH
LFT A PILLAR G'S
FILTER CLASS 60
TEST 1961
10 FEB 61
AP
HS
RL
RESULTANT
30
20
10
0
-10
-20
-30
-40
60
70
50
40
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

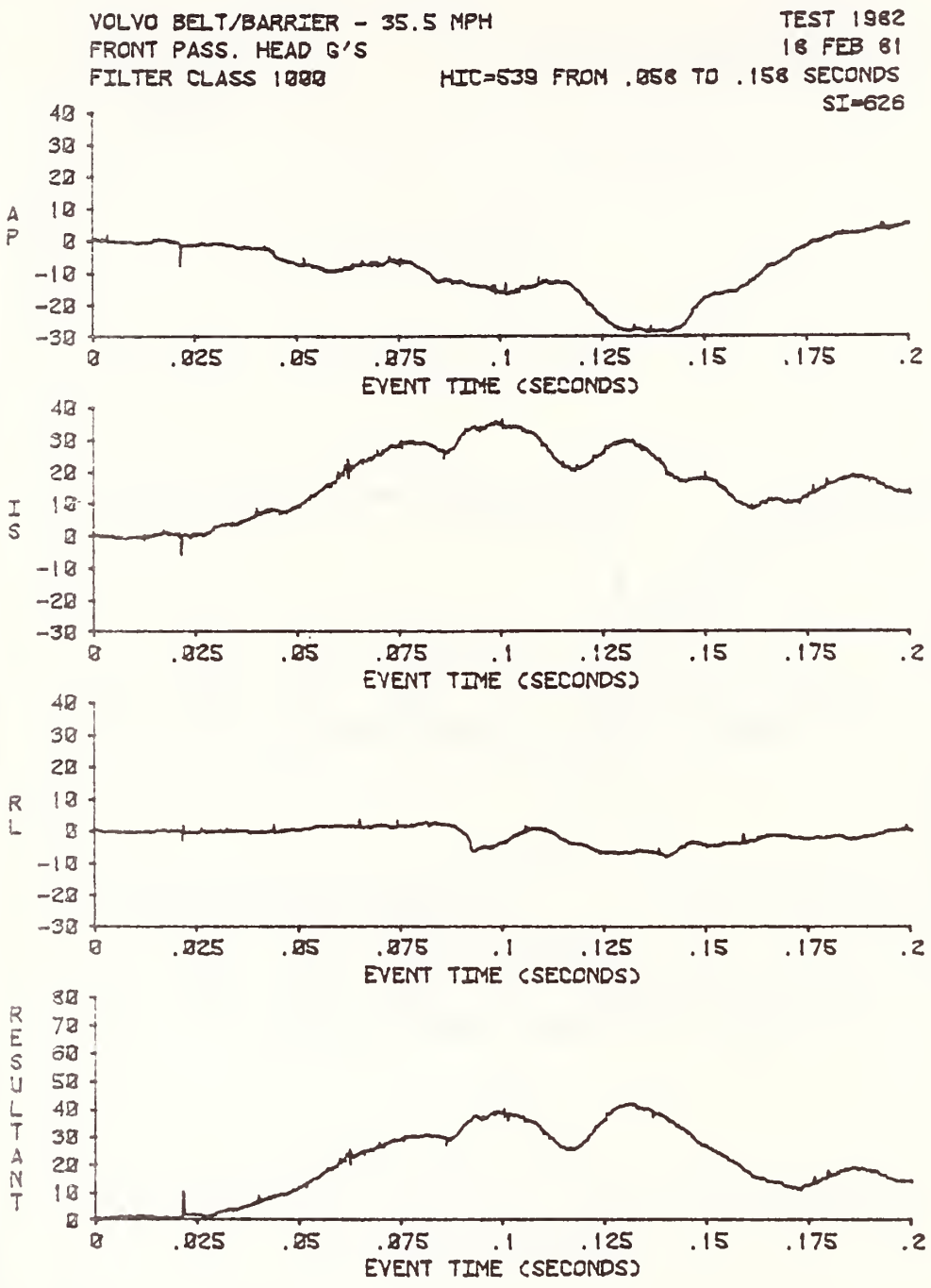

VOLVO BELT/BARRIER - 35.5 MPH
TEST 1962
DRIVER HEAD G'S
18 FEB 81
FILTER CLASS 1000
HIC=499 FROM .066 TO .1122 SECONDS
SI=796
AP
IS
RL
RESULTANT
100
50
0
-50
-100
-150
300
250
200
150
100
50
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

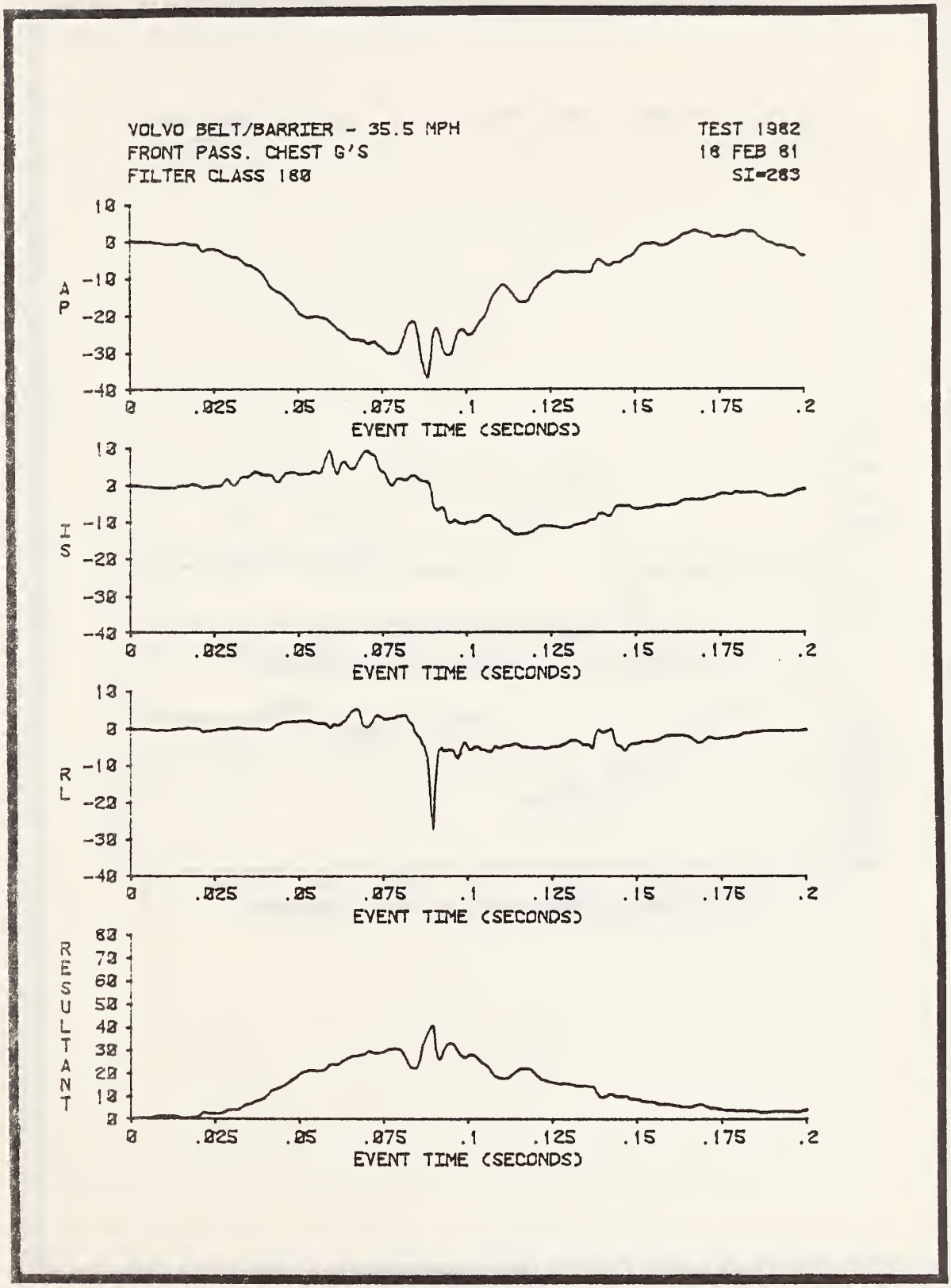

VOLVO BELT/BARRIER - 35.5 MPH
DRIVER CHEST G'S
FILTER CLASS 180
TEST 1962
16 FEB 81
SI=368
AP
IS
RL
RESULTANT
20
10
0
-10
-20
-30
-40
-50
100
80
60
40
20
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)

VOLVO BELT/BARRIER - 35.5 MPH

TEST 1962
16 FEB 81

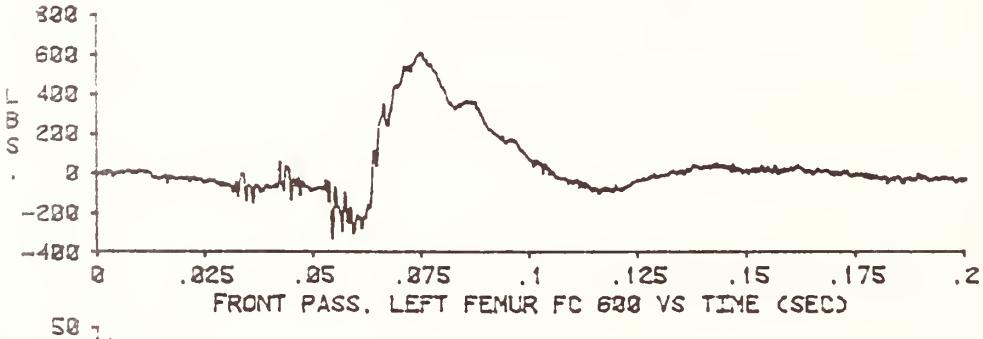


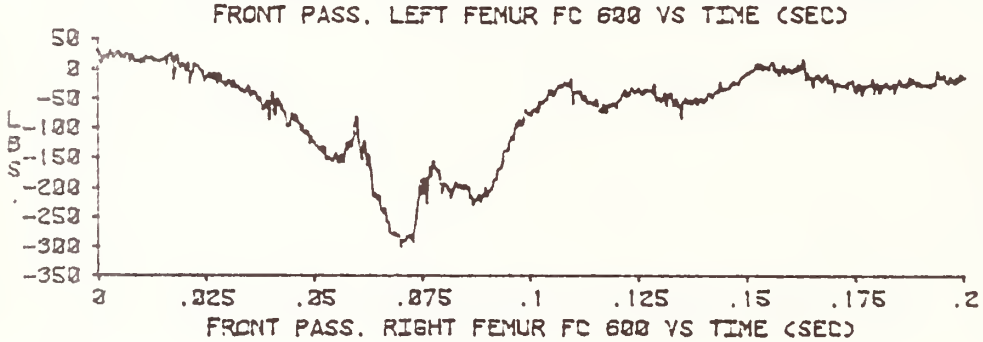

VOLVO BELT/BARRIER - 35.5 MPH
TEST 1962
FRONT PASS. HEAD G'S
16 FEB 81
FILTER CLASS 1000
HIC=539 FROM .056 TO .158 SECONDS
SI=626
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO BELT/BARRIER - 35.5 MPH
FRONT PASS. CHEST G'S
FILTER CLASS 180
TEST 1982
18 FEB 81
SI=283
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)

VOLVO BELT/BARRIER - 35.5 MPH

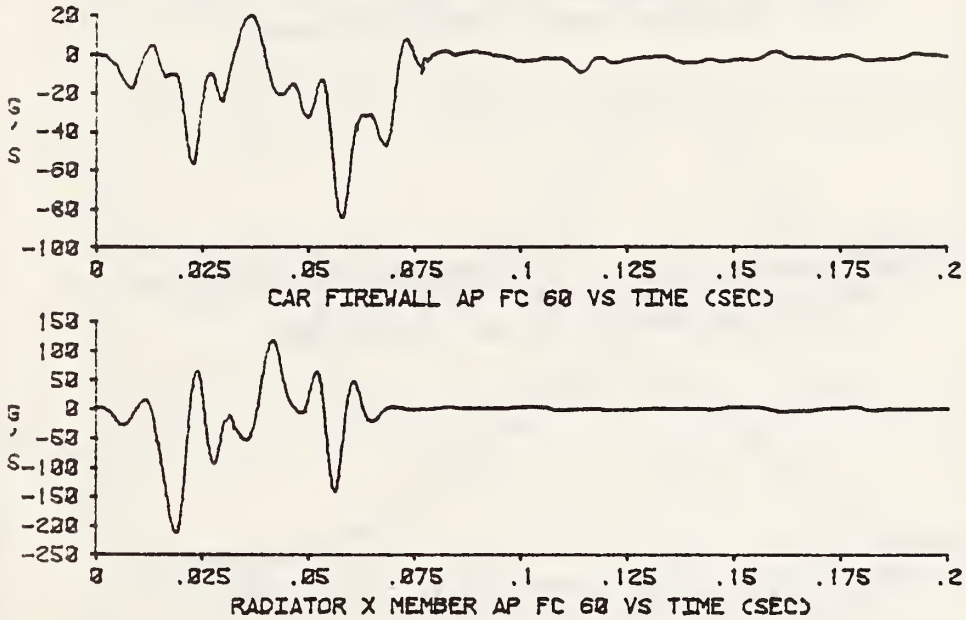
TEST 1962
16 FEB 81





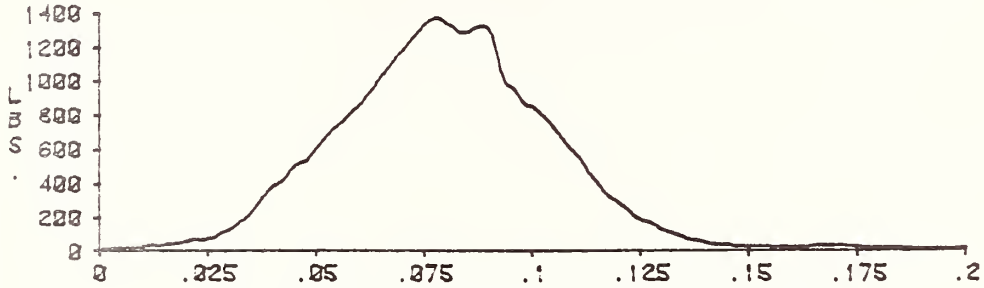
VOLVO BELT/BARRIER - 35.5 MPH

TEST 1962
18 FEB 81

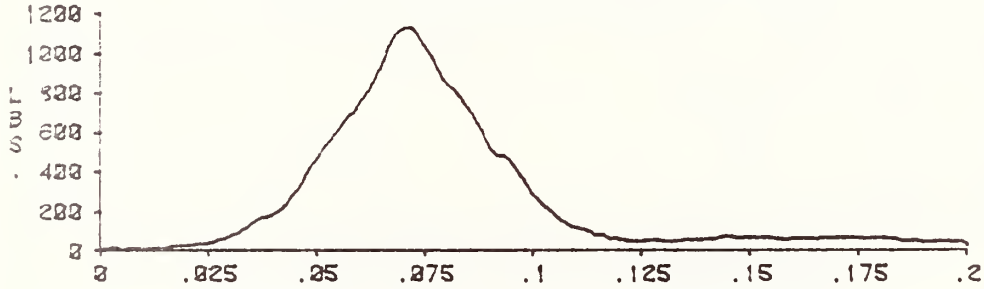


VOLVO BELT/BARRIER - 35.5 MPH

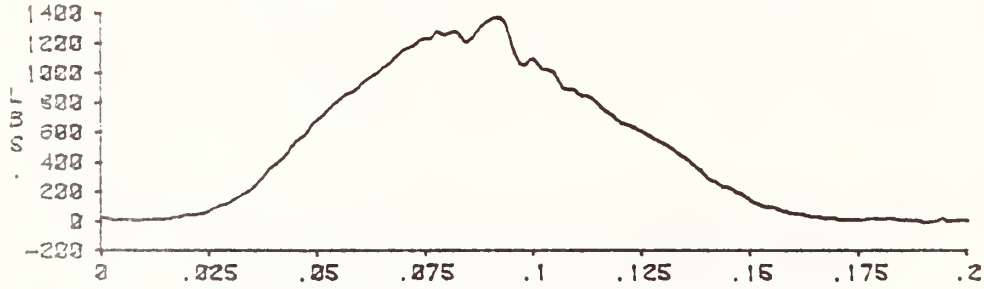
TEST 1962
16 FEB 81



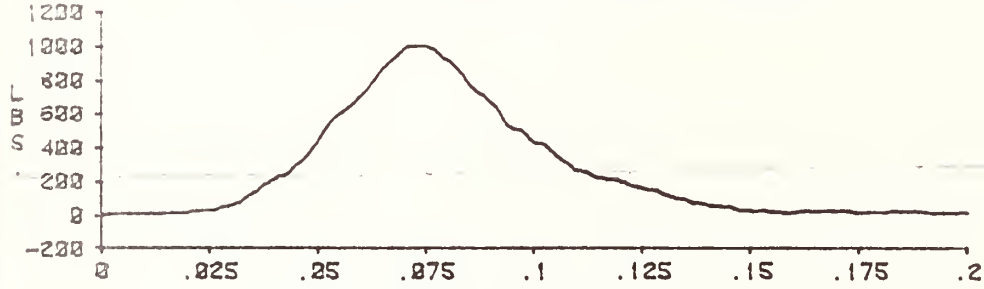
BELT LOAD DRVR TORSO FC 160 VS TIME (SEC)



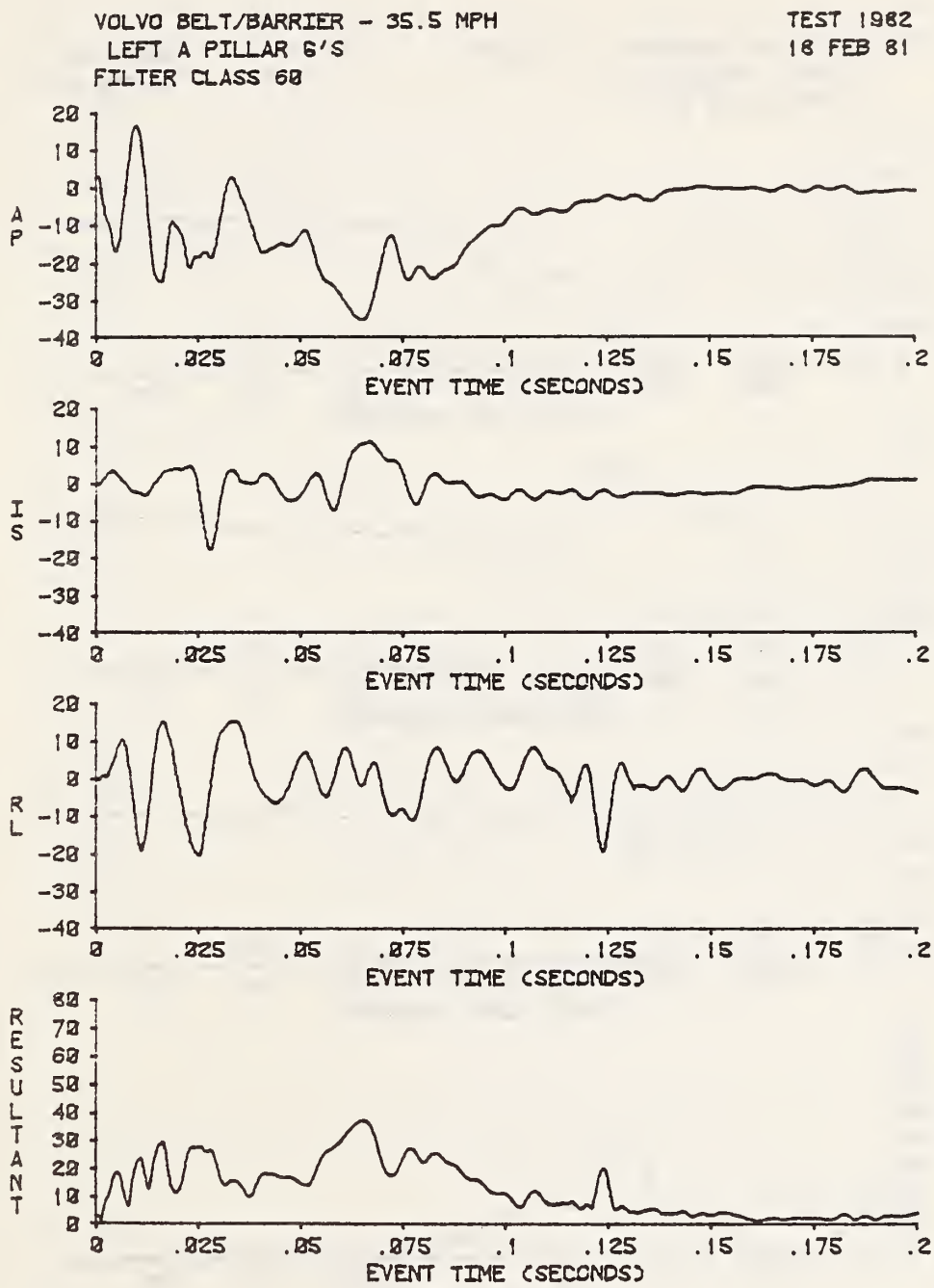
BELT LOAD DRVR LAP FC 160 VS TIME (SEC)

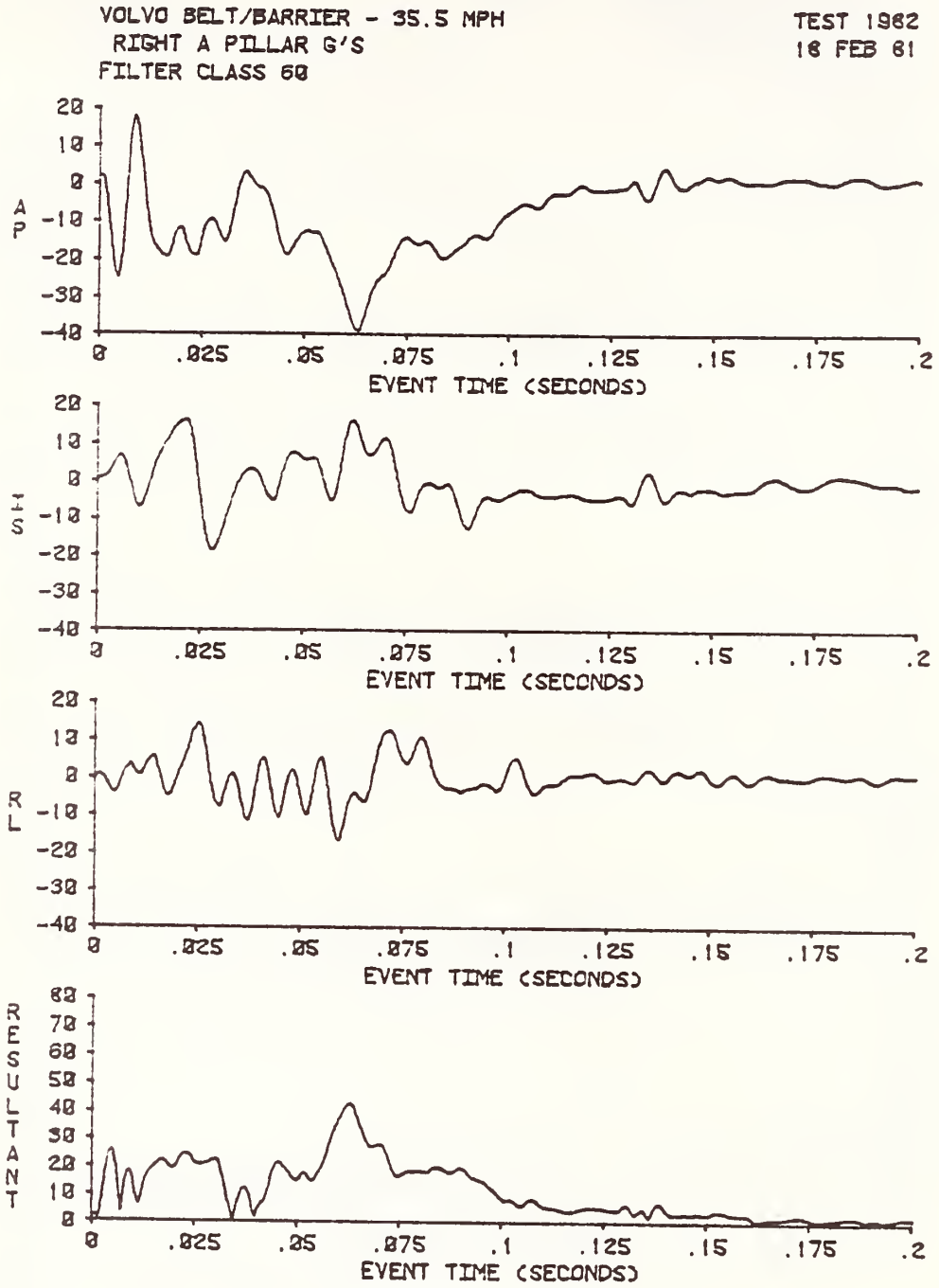


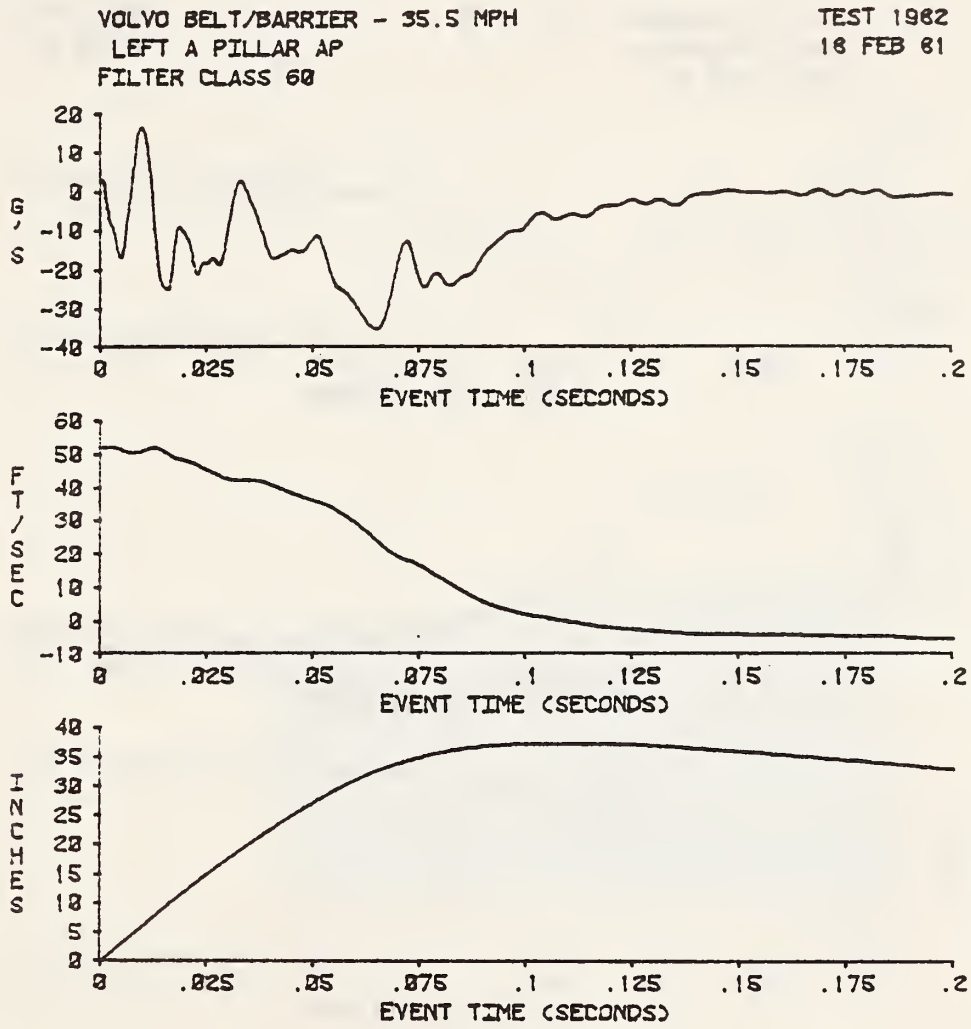
BELT LOAD PASS TORSO FC 160 VS TIME (SEC)

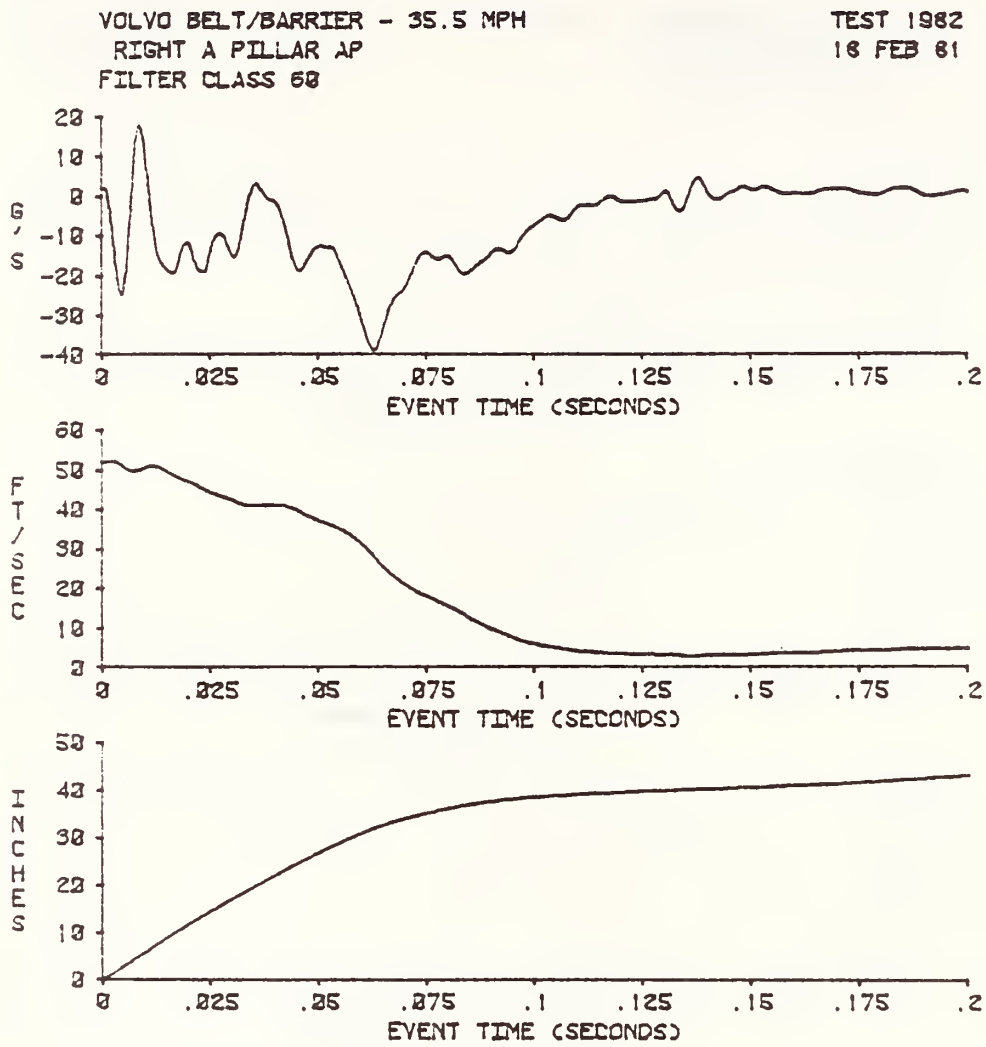


BELT LOAD PASS LAP FC 160 VS TIME (SEC)


VOLVO BELT/BARRIER - 35.5 MPH
LEFT A PILLAR G'S
FILTER CLASS 60
TEST 1982
16 FEB 81
AP
IS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO BELT/BARRIER - 35.5 MPH
RIGHT A PILLAR G'S
FILTER CLASS 60
TEST 1982
16 FEB 81
AP
HS
RL
RESULTANT
EVENT TIME (SECONDS)


VOLVO BELT/BARRIER - 35.5 MPH
LEFT A PILLAR AP
FILTER CLASS 60
TEST 1962
16 FEB 81
G'S
20
10
0
-10
-20
-30
-40
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
-10
EVENT TIME (SECONDS)
INCHES
40
35
30
25
20
15
10
5
0
EVENT TIME (SECONDS)


VOLVO BELT/BARRIER - 35.5 MPH
RIGHT A PILLAR AP
FILTER CLASS 60
TEST 1982
16 FEB 81
G'S
20
10
0
-10
-20
-30
-40
0
.025
.05
.075
.1
.125
.15
.175
.2
EVENT TIME (SECONDS)
FT/SEC
60
50
40
30
20
10
0
EVENT TIME (SECONDS)
INCHES
50
40
30
20
10
0
EVENT TIME (SECONDS)

PHONE	DATE
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